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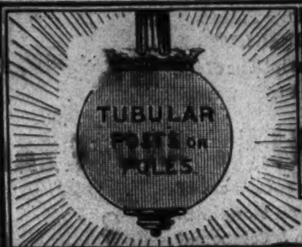

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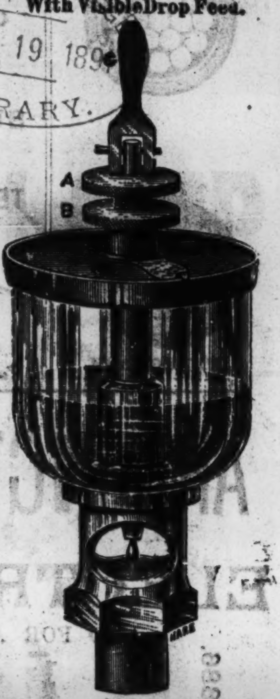

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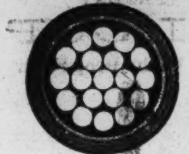

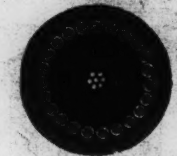

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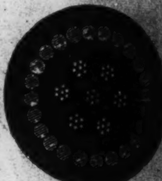

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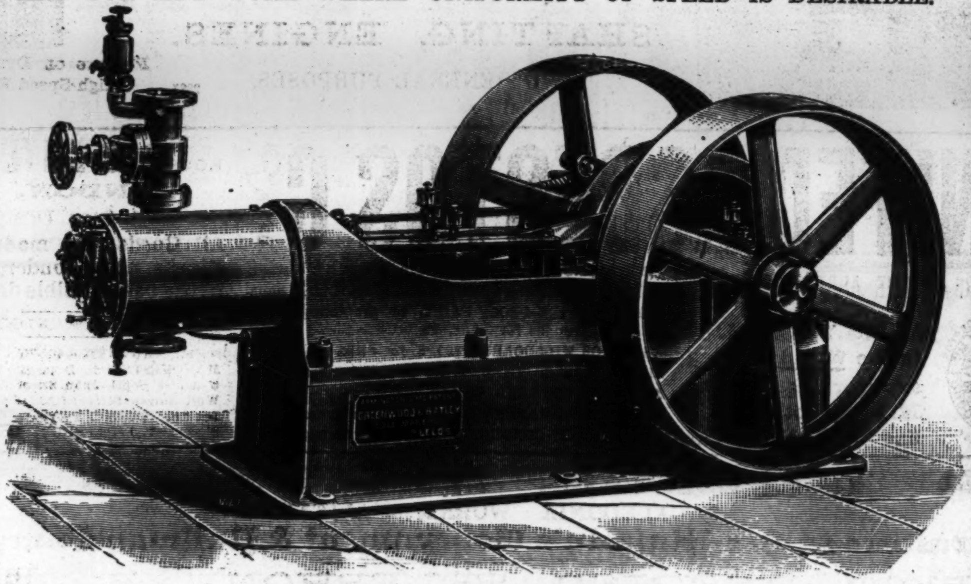

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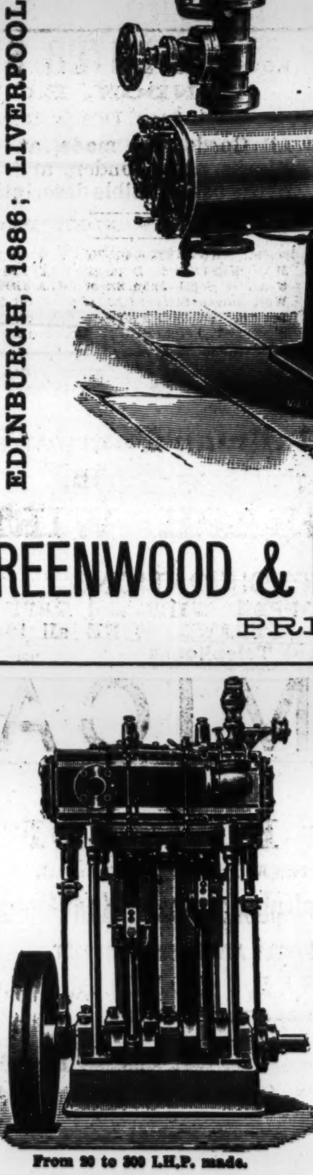

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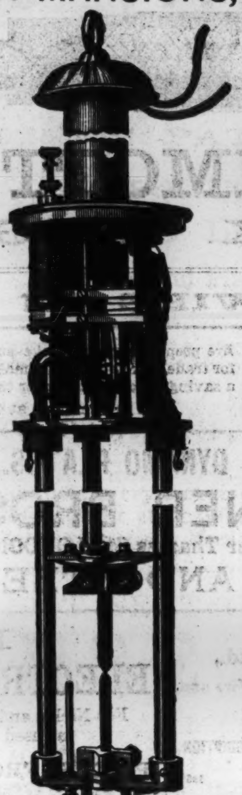

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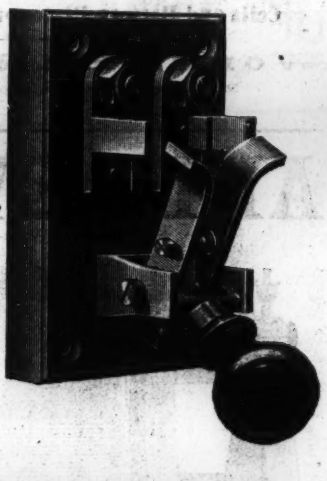

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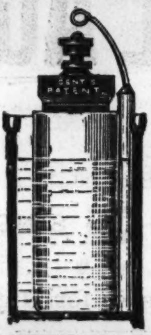

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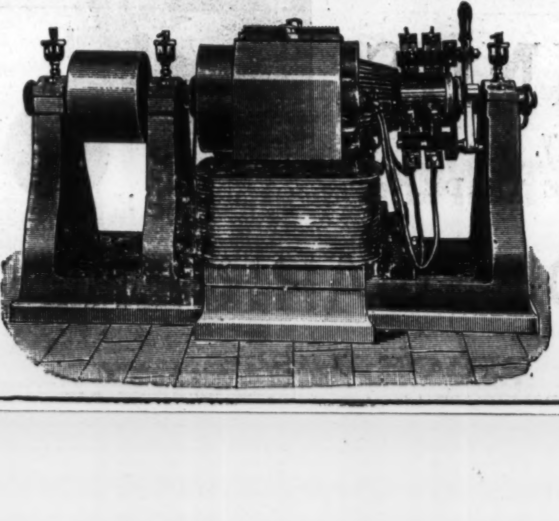

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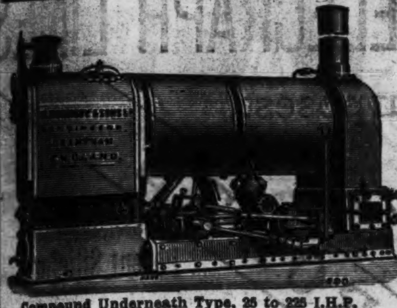

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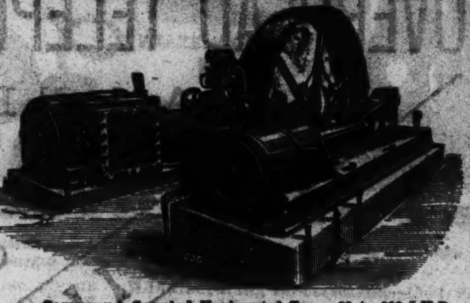

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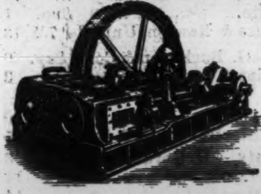

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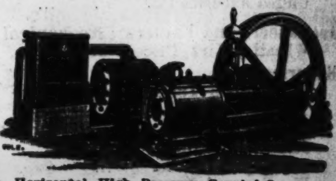

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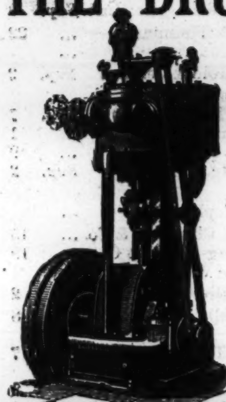

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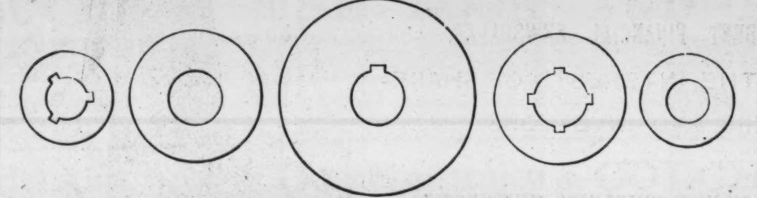

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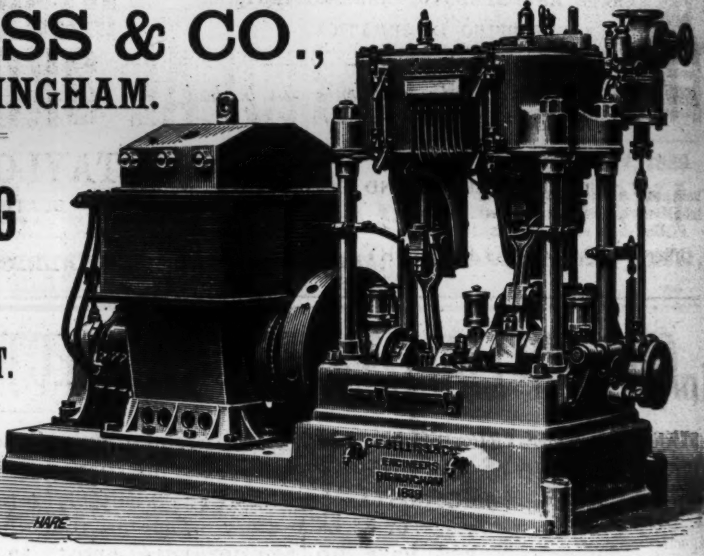

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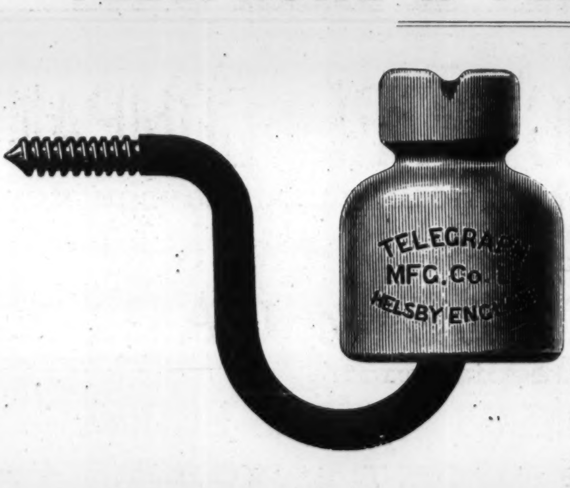

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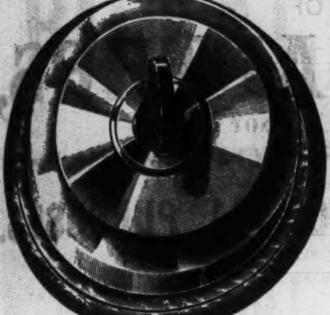

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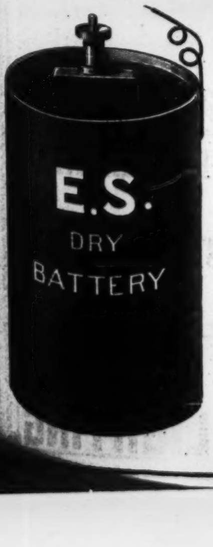

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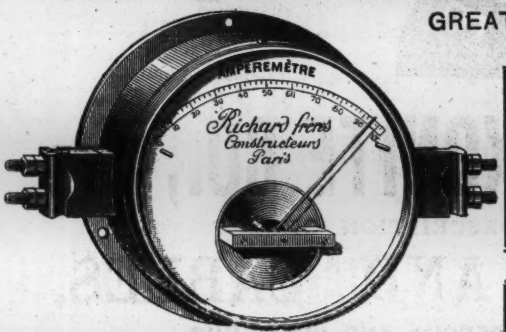

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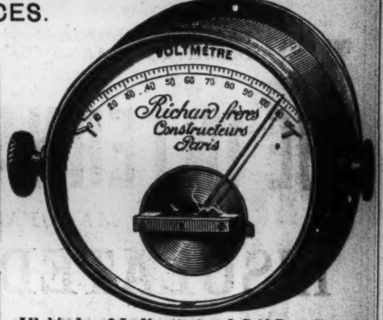

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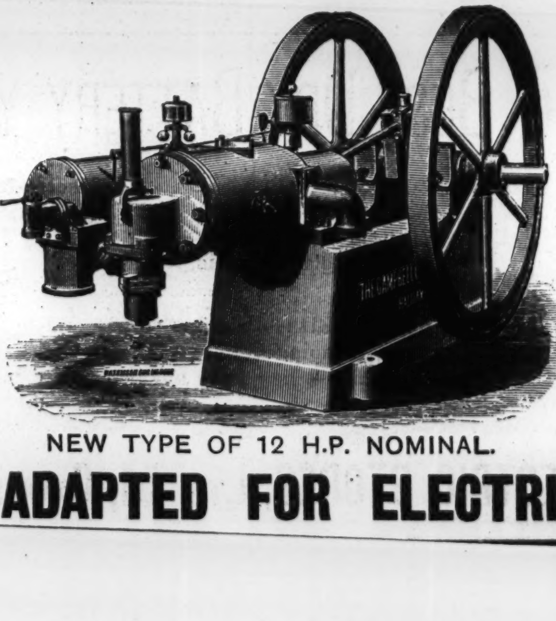

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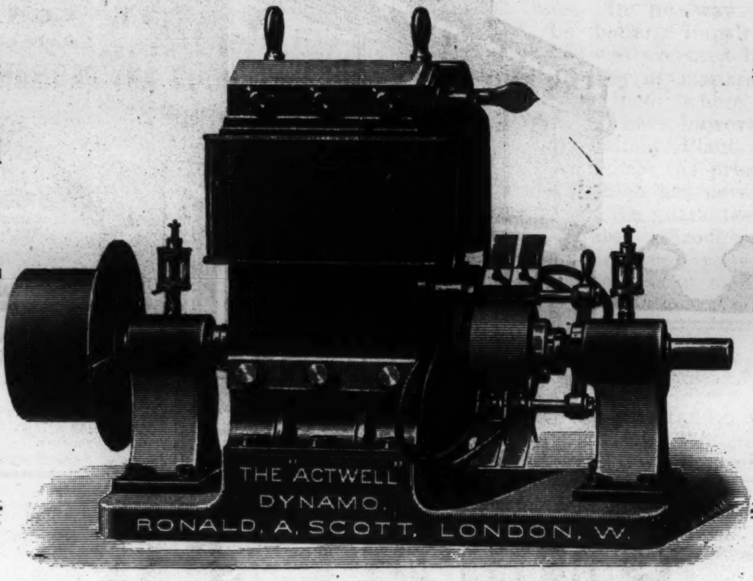
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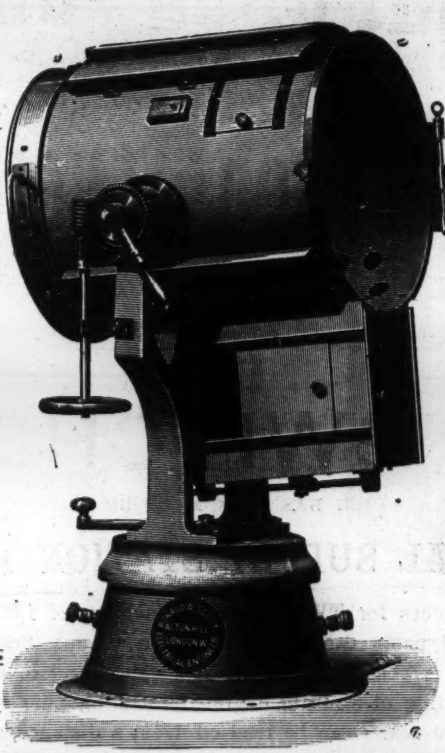

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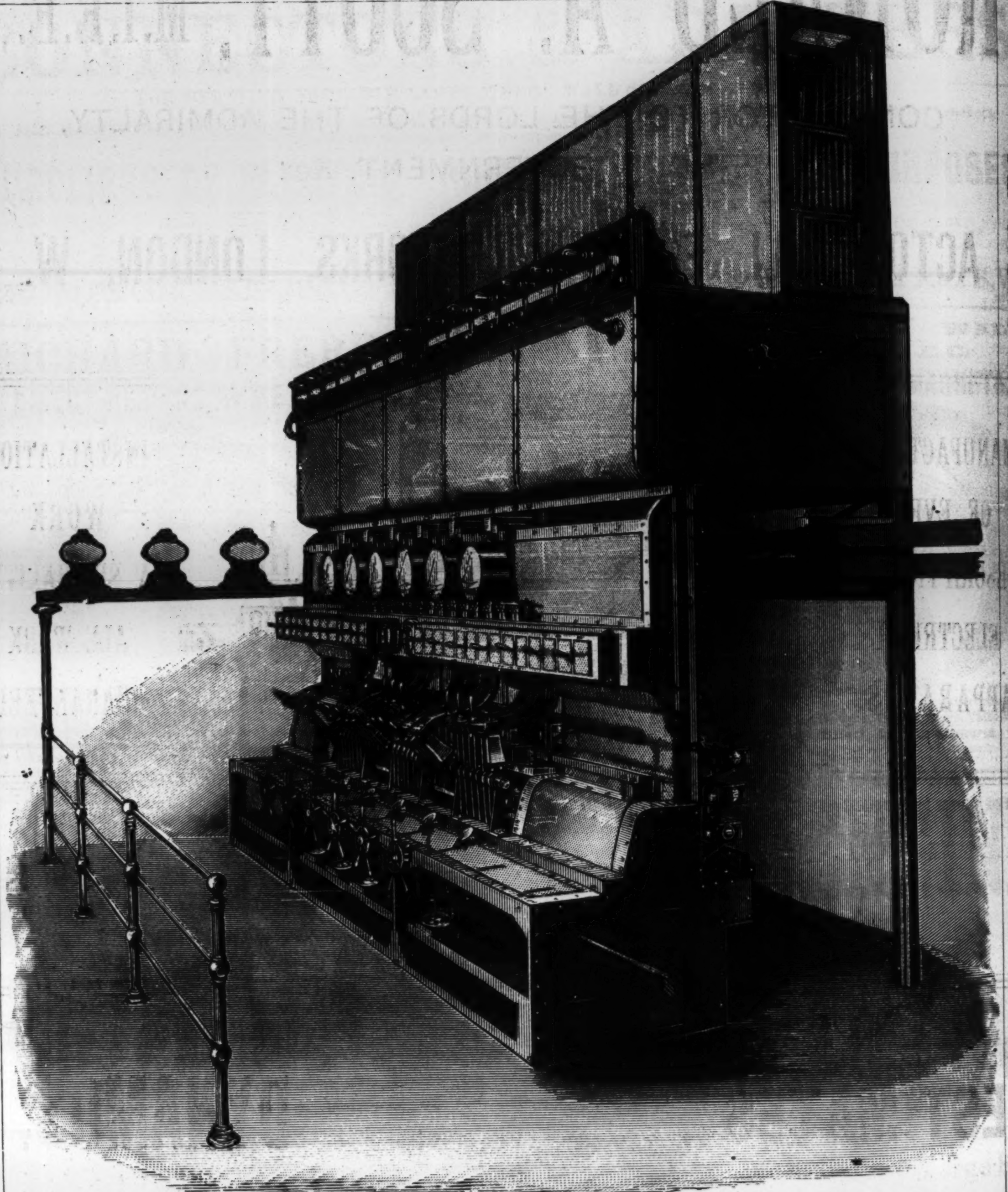

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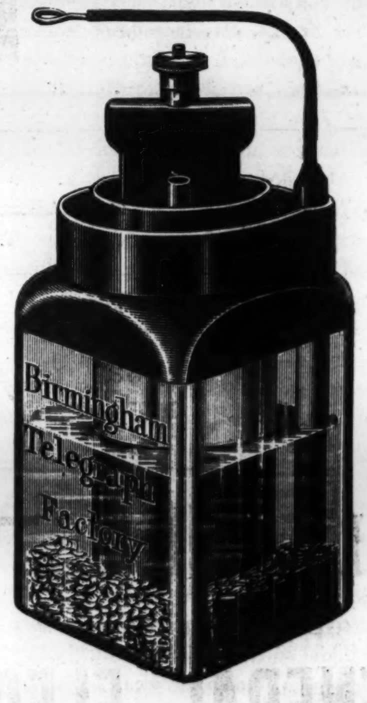

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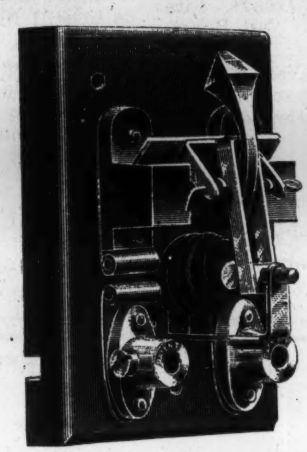

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THE TELEGRAPHIC JOURNAL AND
ELECTRICAL REVIEW.

VOL. XXVIII. MAY 8, 1891. No. 702

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PETROLEUM IN PRIME MOTORS.

THE use of mineral oil as a satisfactory substitute for coal, says Admiral Selwyn, in the discussion on Prof. Robinson's paper, read before the Society of Arts last Wednesday week, entitled "The Uses of Petroleum in Prime Motors," was at a time not more remote than twenty-five years ago considered by a distinguished scientist of that period to be an utter impossibility. Now it has been proved that oil as a fuel has at least twice the heating power of coal, and the use of petroleum or petroleum refuse in place of coal is daily spreading. If the anticipation of the gallant Admiral is not the sanguine vision of an enthusiastic inventor, a still higher value will have to be given to the heat-producing qualities of liquid fuel when compared with coal; but the heat-value ratio of 6 to 1 between the two fuels would appear to be beyond the mark, and approaches to the theoretical value of pure hydrogen.

All classes of mineral oil, from the heavy green oil of specific gravity of 1·110, with flashing point of 98° C., up to the ordinary American kerosene, which flashes at 24° C., can be safely utilised as heat-producers. The heavier oils constitute excellent liquid fuel for steam raising purposes, or they can be converted into oil gas by one of the producer systems, and used with economy in the cylinders of internal combustion engines.

There will be an increasing demand for oil gas producers, since the opinion is fast gaining ground that for horse-powers over thirty or forty, the ordinary gas engine possesses many advantages over petroleum oil engines in which for large powers the vaporisers have been somewhat difficult to work with. By the term oil gas, it is intended to be understood a fixed or permanent gas which when cooled will not condense again—to any extent, at least—to a liquid form; this in contradistinction to the gas, or, rather, *vapour* produced from benzoline, &c., by air gas machines, in which the product is simply carburetted air from which at comparatively low temperatures the hydro-carbon will condense out. The mixture is extremely explosive, and the spirit itself can never be used with expectations of safety. Oil gas has the same property as coal gas of making a leakage soon perceptible by the smell, and in this respect it can claim superiority over water gas. The oil gas made from Scotch intermediate shale oils, costing 4½d. per gallon, will produce 100 cubic feet of rich gas; 9 cubic feet per hour of this is consumed per brake horse-power in a Crossley-Otto gas engine.

The intermediate oils and the kerosene or lamp oils are employed directly in the various patterns of internal combustion engines, and act as their own gas generators. The Priestman—how different from the original importation by the Self-Generator Syndicate!—the Akroyd, and the Knight engines are notable examples of this class of prime motors.

More lately even petroleum spirit has been used in the Yarrow spirit launches. The spirit, only utilised as an evaporating agent instead of steam, is volatilised in a coil which answers to the steam engine boiler, does its work expansively in the cylinder, is condensed and used again. Great care must be taken to prevent leakage. Kerosene oil burnt in a Rippengille stove provides the necessary heat for evaporating the spirit, and supplying, as it does, about 14 per cent. more heat than the spirit, there can be no valid excuse for using so inflammable a material as petroleum spirit, when the oils of high flashing points are more efficient as heat givers. For internal purposes, however, the spirit is more effectual than steam, the latter, at a temperature of 212° F. gives no pressure; on the other hand, at the same temperature, spirit vapour produces a pressure of over 40 lbs. on the square inch; at 300° F. the relative pressures become nearly 126 lbs. for spirit vapour compared with steam at a little over 50 lbs. on the square inch. Excepting for working under pressure, and in closely sealed apparatus, the use of these volatile hydro-carbons should be prohibited.

Since we examined the Priestman oil engine, an improvement has been made, whereby the petroleum vapour is more intimately mixed with cold air, which permits of a higher compression of the charge before firing, and a corresponding increase of power is obtained. Mr. Boverton Redwood recently took part in an enquiry touching the question of the safety of using a Priestman engine at the bottom of a mine, and to investigate and determine whether the use of that engine would produce a combustible atmosphere. The result was a clean bill of health for the engine. Prof. Unwin bears testimony to the unimpeachably good behaviour of this engine at the Plymouth Show, declaring that it worked more quietly, steadily, and easily than the Otto gas engine. There was no hitch of any kind while he had it under his control, and that combustion of the petroleum seemed perfect. The engine worked with 1 lb. of oil per hour per estimated horse-power at full load; at its normal power 1½ lbs. of oil were required per horse-power hour, which was highly satisfactory. The brake H.P. efficiency of a 5 H.P. engine was about 82 per cent. of the indicated power. The compression before igniting was 33 lbs. per square inch. The cost per brake horse-power with oil at 5¼d. per gallon barely exceeded ½d. per hour.

The Akroyd engine also works well. The action in the cylinder is entirely different to the Priestman, as there is an excess of air in the cylinder, which is compressed before the oil is injected. The combustion is complete, but as the air is dry the cylinder requires independent lubrication, as in a gas engine. The Akroyd engine is manufactured by Messrs. Hornsby and Sons, Grantham.

The Knight engine is of the three-cycle type, like the Griffin gas engine using high-piston speed; the ignition is produced by a heated platinum spiral, or for out of doors by the ordinary ignition tube.

The increased application of petroleum for producing power should comfort those people who lament the rapid production and consumption of our coal, for it is estimated that there is oil bearing shale in this country capable of furnishing perhaps 120 gallons of oil to the ton which, as a fuel, is of greater value than all the coal yet discovered in England. This shale will be available to a larger extent should coals rise much in price.

MANCHESTER CORPORATION AND THE ELECTRIC LIGHT.

AT the April monthly meeting of the Town Council, the report of the gas committee on the question of electric lighting in the borough was submitted, and the suggestions contained therein were approved. This report we have already referred to, but it is worth noting that in submitting the report to the council, the member of the gas committee who had charge of it favoured the meeting with his own personal views on electric lighting. He is reported to have said: "Ten years ago he and other members of the council reported upon the electric light question to the council. Since 1881 he had, he believed, seen every installation of the electric light of any moment in England." One would have imagined that with so much experience, the carrying out of the order obtained by the corporation was but a simple matter; but each installation that this member of the council had seen, had simply confirmed his early conviction that electric lighting would not pay. Several instances were given of places that were said not to pay, and that the minimum price of the electric light was equal to gas at 5s. per 1,000 feet; but, of course, all mention of places where the electric light did pay, and was proved to be satisfactory, was carefully avoided. It was very difficult to imagine a more one-sided and biassed statement than that given to the meeting in presenting one of the lamest reports we have ever been permitted to read. The result of the meeting was to authorise the committee to retain the services of three or four electricians of reputation to draw out and report upon some scheme to carry out the provisions of the Act of Parliament obtained for supplying the electric light within the borough.

The committee acting under this authority have secured the services of the following gentlemen—Prof. Kennedy, Dr. Hopkinson, F.R.S., Mr. W. H. Preece, F.R.S., and Mr. Shoolbred—who will in due course report upon the question. We believe, however, that the question will not only embrace the area of supply defined in the Act, but will at the same time contemplate a further extension of the area. It may be mentioned that the special area of supply scheduled is purely a business area, and where little or no supply would be required after dark, the residential area being almost entirely excluded. Locally, the opinion gains ground that the strong opposition of certain members of the gas committee will frustrate the scheme and allow matters to follow the precedent in Leeds; but still there are others who consider that the corporation will overcome the opposition and carry out the provisions of an Act which they have been at some trouble in obtaining; and if it be true that a site for a central station has already been secured, then it would appear that there is really some chance of such an important city as Manchester showing how such things can be done both efficiently and economically. What a splendid opportunity there would then be of giving the worthy alderman who submitted the report a practical insight into the working of an electric installation on a large scale which, perchance, may ultimately produce a revolution in his opinion.

A FUTURE APPLICATION OF THERMO-ELECTRIC BATTERIES.

IF thermo-electric batteries are incontestably the simplest appliance for the direct conversion of thermic energy or heat into electric energy, nevertheless, as far as yield is concerned, they are deplorable transformers, to which for the present, pending some new discovery, we shall prefer the more complex process which consists in producing work by means of a steam or gas motor, and then converting this work into electric energy. Two characteristic figures enable us to compare the two methods of transformation, and to form an idea of the road which must be traversed in order that the thermo-electric battery may compete with the process at present universally employed in industry. A good gas motor expends 800 litres of gas to produce an effective horse-power. This motor actuating a dynamo will expend 1,500 litres to produce one kilo-watt hour. The best thermo-electric batteries now known expend 30 litres of gas per watt-hour, or 30 cubic metres of gas per kilo-watt hour. Hence a thermo-electric battery expends for producing equal quantities of available electric energy, 20 times more gas than does a motor actuating a dynamo. We must add that the most powerful thermo-electric batteries now known do not produce more than 30 to 40 watts, whilst the power of gas motors for driving dynamos has, so to speak, no limit.

The question changes its aspect if we consider the electric energy merely as a bye-product, heat being the primary object of the manufacture. The poor yield of the thermo-electric battery cannot then be viewed as a serious objection to its use, and important researches are being made in this direction, the results of which we shall lay before our readers if practice confirms the results of the first trials. We refer here to a thermo-electric stove, which, whilst serving the purpose of domestic heating, furnishes continually 24 hours daily during entire months, an electric power of 30 to 40 watts per hour, or nearly a kilo-watt hour daily. By utilising this energy for the charge of accumulators, we can dispose of a mean quantity of energy of 800 watt-hours, a quantity sufficient to light each day 25 lamp-hours of 10 candle-power. If these figures, which we give under reserve, are exact, we have the solution of the domestic light question in a good number of cases where a house is not situate near electric leads.

It is fully understood that the thermo-electric stove is heated with coke or coal, and that the heat produced is practically equal to that of other stoves without electric fittings, since the quantity of heat converted into electric energy is less than $\frac{1}{200}$th part of the total heat generated by the consumption of the carbon.

Electricity in Ships of War.

The extent to which electricity is employed in modern warships may be gathered from the following particulars of the electrical outfits of eight vessels recently built and armed by Messrs. Sir W. G. Armstrong, Mitchell & Co., Limited, at their Elswick shipyard. In each of the three 2,675-ton, 19·5-knot, Colonial cruisers, *Katoomba*, *Mildura*, and *Wallaroo*, the electric light installation comprises 267 lamps of 16 C.P. and 37 of 50 C.P.; 262 small and 24 main switches; 240 small and 24 main cut-out fuses. Each vessel is fitted with two yardarm reflectors, containing 8 lamps of 50 C.P., and two semaphore signalling arrangements, consisting of a box fitted with a mirror reflector which throws the light from 4 16-C.P. lamps on two movable arms of a semaphore. All the instruments such as compasses, engine room telegraphs, steering wheels, electrical indicators, &c., are specially lighted. Each vessel has three search light projectors—two of which are movable—and a generating plant consisting of two combined sets of "Willans" engines and "Siemens" dynamos, running at 415 revolutions per minute and giving 300 ampères and 80 volts. With reference to the armament, the four torpedo tubes in each ship are fired electrically from a distance—a duplicate system of wiring being provided in case one wire should be damaged—and the 8 4·7-inch Q. F. guns are also fitted with two alternative methods of electrical firing. In four smaller, 739-ton, 21-knot, Colonial warships, also recently completed by Messrs. Armstrong, viz., the *Boomerang*, *Karakatta*, *Plassy* and *Assaye*, internal electric lighting has not been considered necessary but each has been fitted with a "Tower" engine and a "Siemens" dynamo, giving 100 ampères and 80 volts; one search light projector; one yardarm reflector with 8 50-C.P. lamps and semaphore reflector, &c. Each has, moreover, 5 torpedo tubes, fired electrically from the conning tower, and two 4·7 inch quick-firing guns also fired by electricity. In another recently completed cruiser of Elswick build, the *25 de Mayo*—a vessel of 3,200 tons displacement, 13,500 I.H.P. and 22·47 knot speed—the electrical outfit consists of three steam turbine dynamos manufactured by Messrs. C. A. Parsons & Co., each capable of giving 200 ampères of current at 80 volts; 190 lamps of 16 C.P., 12 lamps of 50 C.P. and two yardarm reflectors; three search light projectors, one of which is in the military top. The three torpedo tubes, two 21 c/m. guns and eight 4·7-inch quick-firing guns, are all fired electrically, while the sights are illuminated by minute incandescent lamps for night service. All these vessels are wired on the double wire system, with lead-cased cables, on the plan originally introduced at Elswick, and the whole of the work has been carried out by Messrs. Sir W. G. Armstrong, Mitchell & Company's electrical staff under the able superintendence of Mr. L. Newitt, with Mr. A. A. Campbell Swinton as electrical adviser.

Some New Specimens of Meteoric Iron.

The meteorite which fell at Collescipoli on February 3rd was shaped like a tortoise and weighed about 4½ kilogrammes. On touching the ground it appears to have exploded, embedding itself to the depth of half a metre. The surface was dark dull, vitrified, covered with divergent striations, dotted over with shining particles, and pitted here and there. The interior was ash-coloured, with a granular structure, and it consisted chiefly of metallic and nickeliferous iron, magnetic iron ore, and black nodules of ferric chromite, and of peforhotite. The meteorite which fell at Ochansk a short time ago has been examined by Von Siemaschko. It possesses a highly bucsiated structure, and consisted of 79·12 per cent. of iron, associated with nickel, cobalt, phosphorus and sulphur. A very magnetic sample of meteoric iron was recently found at Pipe Creek, near San Antonio, Texas. It has been examined by A. R. Ledoux, who finds that it consists of magnetic portion, 30·89 per cent.; non-magnetic portion, 69·11. The magnetic portion consisted of iron, 90·94 per cent.; nickel, 9·00 per cent. And the non-magnetic portion contained silica, sulphur, lime, magnesia, phosphorus and ferric oxide. O. W. Huntington has been examining a specimen from North Dakota, which fell in 1885; it consists of 90·24 per cent. of iron together with nickel, and traces of phosphorus and copper. The iron is so malleable that it can be rolled out into thin ribbon in the cold and it breaks like a soft semi-solid material. The meteorite weighed 4,015 grammes, and from its peculiar shape and appearance appears to be a thick scale blown off from the spherical surface of a large body.

History Repeats Itself.

The following cutting has been sent to us:—"Not long ago an ingenious young cadet of one of our scientific corps applied electricity to wake him in the morning, and boil his coffee. The minute hand of his clock was caused to press two spring contacts together, and thus send an electric current to ring a bell which woke him at the proper time. The current also actuated a small electro-magnet, which allowed some sulphuric acid to run out of a spoon and ignite a match, which in turn lit a spirit lamp placed under the coffee boiler. By the time he was dressed for parade his coffee was ready." The above extract shows how each succeeding generation re-invent. It is more than 30 years ago that Cromwell Varley described to a friend of ours a precisely similar method which he used in his early telegraph days (about '50) to save time, &c. Since then the thing has been done by both big and small. These arrangements were well described in the *English Mechanic* about 1865.

Ships' Compasses and Electric Lighting.

In his lecture on "Electric and Magnetic Screening," at the Royal Institution, Sir William Thomson condemned the use of the "single wire" system of lighting ships by electricity, on the ground that observation has shown it to produce an error in the ship's compass of 3 deg. to 7 deg., every care being taken. It has been argued that the iron hull protects or screens the compass from the deflecting influence of the current, but Sir William declared that this argument was fallacious. He, therefore, recommends the "double wire" system for electric lighting on board ship, that is to say, the use of a going and returning wire, except in the rare and uneconomical case of an alternating current being used. Now the concentric wire system is equivalent, so far as the compass question is concerned, to the two-wire system, and is in fact one of the best and safest ways of carrying out the complete two-conductor system. No doubt Mr. Andrews will appreciate this opinion, which is endorsed by no less an authority than Sir William himself.

THE INCANDESCENT LAMP.*

By THOS. G. GRIER.

INCANDESCENT lighting is now merging into a second decade of commercial life, and any neglect on the part of the electrical fraternity to fully understand the importance which the incandescent lamp plays in this growing industry is suicidal to their interests.

The limited knowledge and the absence of any reliable data on incandescent lamps led the Franklin Institute, in 1884, to invite the manufacturers of incandescent lamps to place samples of their lamps in the hands of an impartial committee of experts for a comparative test. These results were published in September, 1885, and from the official report a few results have been compiled.

Five different manufacturers submitted their lamps, some submitting several batches of different voltages. The lamps were tested for duration of life, and before placing on test their initial efficiency per spherical candle-power was determined.

The results of the tests showed that the greatest depreciation in candle-power was 50 per cent. and the least 33 per cent. This, however, cannot be taken for any comparison as the life of the lamps showed such a great disparity. The depreciation of the Edison lamps, which proved the superior in the test, was 35 per cent. These results are looked upon to-day as of little practical value except as historical record, but they have taught us that lamps are a delicate matter to handle, and whether a lamp is a lamp of value depends on many circumstances.

Since 1884 many other makes of lamps have come on the market, and knowledge gained by experience has both improved the quality of the lamps and cheapened the process of manufacturing. In 1884, lamps were advertised for 16-C.P., $3.00; to-day from 40 cents to 60 cents may be taken as an average price.

Six years now have passed since the Franklin Institute experiments, and we are almost as much in the dark as in the earlier days of the industry. The question of life seems to be the most important factor to be considered from the central station point of view, and to meet this desire various manufacturers frequently guarantee the average life of their lamps. Those guaranteeing the longest life and at the same time proving their guarantee usually get the majority of the business.

There is not the least trouble in making an incandescent lamp for any desired life, as the life of a lamp depends upon the efficiency at which it is burned. John W. Howell, in 1888, published a statement based upon the experiment of the Edison Company, which covered five years of time, and the use of thousands of lamps. In this statement he says the life of a lamp burned at two watts efficiency was practically zero; at three watts per candle it was 1,000 hours; at four and three-fourths watts per candle-power it was 16,000 hours. This at once shows that the question of life is merely a question of circumstances and may, or may not be, advantageous.

The object of an incandescent lighting station is to produce light. It is necessary to develop electrical energy, but it is the lamp that transforms this electrical energy into light. The electrical energy represents the dollars of the investor and operators of the station, and it is most important that it should be used with the greatest economy to obtain proper reward for the investor. This, of necessity, brings into the question the lamp used; the life, the cost, and the efficiency being the three considerations.

To bring the matter to a point at once we will assume conditions which are perfectly feasible and within the bounds of possibility. First, we will consider that a lamp burning at 4½ watts efficiency will depreciate but a minimum for the first 1,000 hours. We will consider this lamp and the cost of operating it. A lamp at 4½ watts efficiency and 16 C.P., burning for 1,000 hours, would require a total expenditure of electrical energy of 72,000 watt hours. This, at 1 cent for 50 watt hours would be $14.40, for the current, and, adding 50 cents for the cost of the lamp, would make a total cost of $14.90, for burning this lamp 1,000 hours. The efficiency of another lamp is 3½ watts per C.P. We will not say how many lamps will have to be replaced in the 1,000 hours, but just assume that the efficiency of 3½ watts per C.P. is maintained throughout the 1,000 hours. The total expenditure of energy on this basis will be 56,000 watt hours, which will cost at the rate of 1 cent for 50 watt hours, $11.20. Adding 50 cents to this for the cost of the first lamp, makes it $11.70, leaving a difference in favour of the 3½ watt lamp of $3.20, which, of course, will have to be used to a certain extent in replacing the lamps; but allowing that a 3½ watt lamp will maintain its efficiency for 333 hours, we will merely have to pay $1.00 additional for replacing lamps and have a net saving of $2.20. This, though an assumption, is not distorted, for lamps from 3½ to 4½ watts efficiency are on the market. And yet, many a station is being operated with lamps of a lower efficiency than 4½ watts, and they wonder why it is that their dividends are smaller than those of other plants. It is the incandescent lamp that will make or break the dividend-paying record of the central station and it should be considered with the utmost care. The assumption has been made and the question been analysed. The lack of actual data makes it necessary to assume and analyse the question as it has just been done. However, the London ELECTRICAL REVIEW has published some facts which will be analysed, as this assumption has been, and will show immediately the advisability of maintaining efficient lamps on a circuit, even though their life be short.

The London ELECTRICAL REVIEW published an account of a test on Edison-Swan lamps and the results were presented in tabulated form, giving the initial candle-power, the initial efficiency, and the total watts used on the lamp. A test of 1,000 hours duration was started, and at the end of each 100 hours observations were made as to the candle-power and the total energy, the efficiency of the lamps being computed and placed in the table. The first four columns of the data are furnished by the ELECTRICAL REVIEW, the other columns are deductions drawn from the first four columns.

Hrs.	C.P.	Watts per C.P.	Total watts.	Average of each 100 hours.		Cost figured on the basis of 1 cent for 50 watt hours.	
1	2	3	4	5	6	7	8
				Average C.P.	Average total watts.	Cost for each 100 hours.	Cost of 16 C.P. at each 100 hours.
0	19·3	3·34	64·46				
100	18·8	3·45	64·86	19·05	64·66	$1.293	$1.08
200	17·2	3·79	65·19	16·00	65·93	1.300	1.16
300	15·6	4·10	63·96	16·40	64·57	1.297	1.26
400	15·2	4·17	63·38	15·40	63·67	1.270	1.32
500	14·8	4·29	63·49	15·00	63·44	1.268	1.35
600	14·4	4·38	63·07	14·60	63·28	1.264	1.38
700	14·1	4·50	63·45	14·25	63·26	1.265	1.42
800	13·3	4·68	62·24	13·70	62·85	1.257	1.47
900	12·4	4·90	60·76	12·85	61·50	1.230	1.53
1,000	12·0	5·00	60·00	12·20	60·38	1.207	1.58

Column 7 shows what the customer pays each 100 hours for the lamp he is using. Column 8 shows what he pays for each 16 C.P. of light he gets for each of the 100 hours. These figures are computed upon the average of the observations; that is, for the first 100 hours the average candle-power produced is taken, and so on, for each succeeding 100 hours. The cost of the electrical energy used in the estimate is one cent. per 50 watt hours, the prevailing price at the present day.

The potential in these experiments was constant, the same as any ordinary central station endeavours to maintain. The resistance of the filament increases as the lamp continues to burn and the total energy used, when the potential is constant, decreases, and the lamp takes less current to a small extent than when it starts to burn. The relation of the candle-power to the total energy shows, that, though less energy is used as the life continues, the economy of the lamp is greatly lessened because the light produced decreases (due to the depreciation of the filament and the discolouration of the glass), in a much greater proportion than the total energy.

The financial results in the above table are very clear and plain, and any one would say at a glance, allowing that a 16 candle-power lamp costs 50 cents, that it would not cost the consumer a cent more for light if he bought a new lamp at the end of 900 hours, for the saving in current would pay for the lamp; that much is apparent.

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* Abstract of a paper read before the Chicago Electric Club.

Tables were submitted showing that for this grade of lamp at the price of current and price of lamp assumed, though the lamp will last 1,000 hours, it is better to throw the lamp away at the end of 400 hours and use new ones. Seventy-five cents per lamp will be saved every 1,000 hours by replacing the lamps every 400 hours instead of keeping one lamp in 1,000 hours.

If the lamps were cheaper and the currents the same or dearer, it would be cheaper to replace the lamps still oftener than 400 hours. If the current was but half of what is assumed, that is, if the current cost but one cent for 100 watt hours, it would be cheaper to replace the lamps every 700 hours, cheaper by about 17 cents, for every 1,000 hours.

It is not a question of the life of a lamp alone that should determine what lamps should be used, but also the efficiency of the lamp, cost of current and price of lamp. A mathematical equation should be formed taking all these factors into consideration before the matter should be decided by the central station. Reliable data on the majority of the makes of lamps is not obtainable, and it has been necessary to treat the matter from assumption and from analysing such data as have been published; but even from mere assumption it is, without doubt, an assured fact, except when the current is extremely cheap that an efficient, short-lived lamp is preferable to an inefficient long-lived lamp.

In making this mathematical equation, the end in view is to determine the efficiency at which the sum of the costs of power and lamps is a minimum, and in order to do this the rate of variation of life of a lamp with its efficiency should be known. This variation would have to be given by the manufacturer. To give this equation in the shape of a formula we will assume symbols to represent the various factors.

Let A = the number of watt hours required by a 16 C.P. lamp, A 16 would represent the efficiency per C.P.
„ B = the life of the lamp at A 16 efficiency.
„ Y = the cost of a 16 C.P. lamp.
„ X = the cost of a watt hour delivered at the lamp.

The value of A and B must be ascertained from the manufacturer.

To obtain the cost of a watt hour, or X, delivered at the lamp, the mean current at the station must be determined. The wires and devices have been figured for a certain loss for maximum current. The energy in transmitting the mean current would bear the same ratio to the percentage, figured for the maximum load, as the mean current does to the maximum current. This amount of energy must be subtracted from the total energy developed, and the remainder will give the amount of energy used in the lamps. The total operating expenses, less the cost of the lamps, divided by the total watt hours delivered at the lamps will give the cost of one watt hour.

The cost of operating a 16 C.P. lamp for an hour would be the cost of a watt hour multiplied by the number of watts required by the 16 C.P. lamp, or $X \times A$.

The proportion of cost for replacing lamps would be the price of the lamps divided by the life or $Y \div B$.

The most economical point to run the station would be when the sum of the renewals and the cost of the energy is a minimum or expressed in a formula when $(Y \div B) + (X \times A) =$ a minimum.

To give an example of this we will assume the following conditions. Let cost of lamp = \$0.50 cents; efficiency, $A \div 16 = 4$ watts, or $A = 64$ watts, let $X = \$·00016$, an average cost of electrical energy (being ·8 of a cent for 50 watt hours); and the life of lamp 1,000 hours, and substituting these values in the formula we have $·501,000 + ·00016 \times 64 = ·0005 + ·01024 = \$·01074$.

Another lamp costs 60 cents, its efficiency is 3 watts or $A = 48$ watts. X = the same as in previous case, \$·00016, and the life of lamp 300 hours, substituting these values in the formula, we have $·60 \div 300 + \$·00016 \times 48 = ·002 + \$·00768 = \$·00968$.

The result shows that a lamp costing 60 cents, and having a life of only 300 hours with 3 watts efficiency, makes the operating expenses of the station less than if the lamp was only 50 cents and had a life of 1,000 hours with 4 watts efficiency, in fact, the 3-watt lamp is cheaper even though the 4-watt lamp cost but one cent and had a life of 10,000 hours, for the cost of the energy alone for the 4-watt lamp is in excess of the sum of the cost of lamp and energy in the case of the 3-watt lamp. The question is governed very much by the cost of the energy.

The success or failure of electric light central stations as a dividend earning investment, is of the utmost moment to the agents, manufacturers of electric light apparatus and others who desire to promote the business. It is necessary for the success of those desiring to promote the electric light business that the electric light central stations make money. For the electric light central stations to be financially successful, those operating them should be convinced of the importance of using efficient lamps and of renewing them as soon as their efficiency materially depreciates.

NOTE ON THE CHEMISTRY OF THE ACCUMULATOR.

WHEN a secondary cell is charged and discharged the operation is accompanied by a chemical change in the electrodes and the electrolyte, as well as by an evolution of gas. Now, in order to arrive at an accurate appreciation of the nature of the chemical changes which take place during this process, it would be necessary to resort to chemical analysis and to determine the composition of the electrodes and electrolyte both before and after charging, also to collect and examine the gases given off. These gases, which consist of oxygen and hydrogen, would only require collecting separately and measuring.

The change in the electrolyte is readily ascertained, but that in the electrodes presents some difficulty; it is, perhaps, best determined by an indirect method by charging each plate of the cell separately, using as the second pole an electrode the chemical composition of which remains unaffected. In such a combination the change in the electrolyte is due solely to the reaction which takes place between it and the electrode, and to the gas evolved. The change in the composition of the electrolyte can be determined, also the quantity of each gas evolved, and from these data the change that has taken place in the electrode is ascertained.

M. Cantor has recently been applying this principle in the study of the chemistry of accumulators, particularly to the study of the changes which take place in the negative plate of a secondary cell, consisting of lead coated with a mixture of lead oxide and sulphate. The plate is so arranged that it forms the cathode, whilst platinum forms the anode, in a solution of sulphuric acid which is undergoing electrolysis.

The following results were deduced from the examination and measurement of the gas evolved and the determination of the change in the electrolyte:—

The lead oxide contained in the plate is first converted into sulphate.

The hydrogen, which is formed electrolytically, reduces the lead sulphate with the formation of sulphuric acid and metallic lead.

The freshly reduced lead decomposes the sulphuric acid, with evolution of hydrogen and the formation of lead sulphate.

These two reciprocal processes continue until a condition of equilibrium is reached, when the cell is charged.

It is to the local action between freshly reduced lead and sulphuric acid that those phenomena are due which led Streintz and others astray. Streintz, in conjunction with Aulinger (*Annalen Phys. Chem.*, series [2], No. xxvii., p. 178), formerly advanced the theory that the hydrogen plate is the seat of the decrease of the electromotive force of the secondary cell.

In another paper published in the same journal (series [2], No. xxxviii., p. 344), Streintz adduced experimental evidence in favour of this theory. He experimented on the charging and discharging of secondary cells during discharge, the potential of the positive plate remaining practically constant, and of a value to which that of the negative plate gradually approximates. In cells containing two negative plates and only one positive plate, each negative plate may be discharged and the potential brought to that of the positive plate, while the latter remains practically unaltered.

Streintz, in this connection, studied the effect of current density on the potential differences, and he was led to conclude that lead has in a very marked degree the power of *occluding* hydrogen; the occlusion being, apparently, similar in character to that observed in palladium.

But Cantor says that it is to local action between freshly reduced lead and sulphuric acid that those phenomena are due, which led Streintz and others to conclude that the lead of accumulators has the power of occluding hydrogen; and Cantor denies that lead possesses this power.

For the complete paper *vide Monatshefte*, ix., 433—451.

ON KERR'S MAGNETO-OPTIC PHENOMENON IN THE CASE OF EQUATORIAL MAGNETISATION OF IRON.

DURING a series of experiments carried on in 1877 and 1878, Kerr found that on the reflection from magnetised iron of light polarised in a plane parallel or perpendicular to the plane of incidence, there arises in the reflected ray, in addition to the component furnished by the metallic reflection, another component polarised in a plane at right angles to this one. In order to give an exact explanation of this phenomenon, it is necessary that the amplitude and phase of the magneto-optic component, and its relation to the angle of incidence, should be determined. This determination, in the case of iron magnetised parallel to the plane of incidence and to the reflecting surface, was recently made the subject of an investigation by R. Sissingh, and the results of his experimental work are given in *Wiedermann's Annalen*, vol. xlii., p. 115 (1891). In the original paper, the results obtained are compared with the well-known theory of H. A. Lorentz, which was first published in 1883 in the *Verslagen en Meeded. der Acad.*, Amsterdam, Reeks 2, Diel xix.

If the polariser is perpendicular or parallel to the plane of incidence, and the analyser in a plane perpendicular to the polariser, the reflected light after magnetic reflection will not be extinguished by the analyser, because the magnetic component of the light does not pass through the analyser without being weakened. By rotating one or both Nicol prisms, however, the intensity of the light can be reduced to a minimum or zero. These minimum or zero-rotations can be used for determining, as Prof. Van de Waals has shown, the amplitude and the phase of the magnetic component of light.

Sissingh first deduces the formulæ which serve to determine the amplitude and phase of this magnetic component in the case of a bundle of incident rays polarised parallel to the plane of incidence.

The apparatus employed in these experiments is sufficiently interesting to warrant some description. The mirrors were ground on iron rings which were encircled by seven layers of windings of copper wire 1·5 to 2 mm. thick; the coils did not project over the surface of the mirror. The current was furnished by 15 common Bunsen cells, arranged in five sets each, containing three cells in parallel, the sets being joined up in series. The magnetisation was measured by the method described by Rowland in the *Philosophical Magazine*, series (4), vol. xlvi., p. 140. In the current issue of this magazine, we may notice that Sissingh's paper is given in full, with all its mathematical details.

In the centre of the mirror, for a magnetising current of 15 ampères, the value of the magnetisation was 1,400 C.G.S. units per unit volume. The mirror was nearly saturated. The magnetism increased 8 per cent. for a rise of current from 7·5 to 22 ampères, and only 2 per cent. between 15 and 22 ampères.

The rings of iron had the advantage that small masses of iron could be strongly magnetised, and a spectrometer used for the investigation; the diameter was 10 cm., the thickness 0·6 cm., the length of the mirror 3 cm., and its breadth 2·8 cm. The optical constants were determined by a Babinet's compensator.

In these experiments sunlight or electric light was used: the latter was furnished by a Siemens lamp, which could be displaced by the observer in a vertical direction. Beside the mirrors and Bunsen cells there were employed a collimator to give the parallel bundle of rays, a polariser and a spectrometer, these being so arranged that they could be moved round the edge of a circular platform. A considerable portion of the paper is taken up with a minute description of what may be called the accessory apparatus, and the manner of using it, and for this we must refer our readers to the original paper.

In the observations that were made, it was necessary to be very careful that the reflection took place exactly at the centre of the mirror, since the magnetic spectrum showed that only in this position are the lines of force parallel to the reflecting surface; and in order to eliminate entirely the influence of a normal component of the magnetisation, the section of the incident pencil of light was reduced to a few square centimetres.

The zero and minimum rotations were determined for various angles of incidence with two mirrors. These angles were so chosen that the difference in phase of the metallic reflection varied from one to the next by $\frac{1}{16}$th of a wave length, except for angles less than 36°, when the differences were $\frac{1}{2}$ wave lengths. All the results are tabulated and compared, and from them the amplitude and phase of the magneto-optic component, and its relation to the angle of incidence, are deduced.

The observed and calculated amplitudes agree with each other within the limits of experimental error, but there appears to be a constant difference between the observed and the calculated phases; the deviations from the mean value lie within the limits of error. The difference is nearly 90°, and perhaps this points to a difference in the behaviour of ordinary electric currents, and the periodic motions of the electric theory of light.

The influence of magnetisation on the reflection at the surface of iron was discovered by Kerr, but he gives only the sign and not the magnitude of minimum rotations. His results, however, agree with Sissingh's observations.

The observations recorded by Sissingh in this investigation furnish an accurate representation of magnetic reflection, which, on comparison with theory, assumes a simple form. In order to demonstrate this clearly, he has compiled a table of the constant quantities, and the relation between these and the observed quantities, which suffice to fully determine metallic and magnetic rotation. But although the relations of the amplitude and phase to the angle of incidence are determined by these observations, further investigation is necessary to ascertain the cause of the very marked dispersion first found by Righi, and also confirmed by Sissingh, during this investigation.

THE ELECTRICAL WORKS AT FIUME.

[FROM OUR OWN CORRESPONDENT.]

YOU have recently published the description of an important alternating transformer installation which is at present being erected at Intra, in order to distribute electricity to a series of towns and establishments, both for lighting and for the transfer of power.

I am now in a position to report to you on a not less interesting installation which the International Electric Company of Vienna is carrying out at Fiume, a part of which, as I have previously informed you, is already in activity.

We have to consider the Fiumese electrical works of the Vienna Electrical Company, designed in the first place for lighting up the Fiumese elevator, and for setting it in motion electrically, and besides to light up the station of the Royal Hungarian State Railway, as well as the entire harbour and all the accessory warehouses and spaces.

The elevator erected by the Hungarian Government at the harbour of Fiume, for the purpose of giving an impulse to trade, is a structure three stories in height, built in the lower portion of iron and stone, whilst the entire upper part consists principally of wood, covered with corrugated iron.

On account of this circumstance the working of the elevators must be effected by means of motors which present absolutely no danger of fire. Hence both steam and gas engines are at once excluded.

Hence, and also on account of the peculiar arrangements for working, the employment of electric motors becomes necessary, and as the illumination of the harbour, the railway terminus, and all objects therein contained was to be effected simultaneously, and as the distances were several kilometres, the system with alternating current transformers was brought into use.

There are set up three alternating current generators of the Zipernowsky type, A_6, each for 80,000 watts, with an E.M.F. at the terminals of 2,000 volts, and a rotatory speed of 360 turns per minute, with the accompanying exciting machines.

Each such arrangement, consisting of an A_6 and its exciting dynamo, is driven direct by a 125 H.P. engine. For generating steam, there are used three Babcock-Wilcox boilers, each with a heating surface of 150 square metres.

This definitive installation, which is now being set up, is to come into action in August. In the mean time—as previously mentioned—the lighting and the working of the elevator and of the receiving warehouses of the Hungarian line are managed by a provisional installation erected for the purpose upon a plot of land supplied by the railway, and consisting of an alternating current machine, A_6, with its exciter, motors, and a temporary locomotive boiler.

By the alternate installation there will also be driven three motors of 20 H.P., constructed for E.M.F. of 2,000 volts, and consequently branching off directly from the primary net.

For the present there are set up in the room of the elevator six alternating current motors of 10 effective H.P. each, which work with an E.M.F. of 100 volts, and are connected to the conductive net coming from the secondary terminals of the transformers.

The motors here set in action transmissions which serve for working partly of bands which raise the grain by adhesion to the upper storeys, and partly for the so-called elevators which carry the grain in pockets fixed to the bands.

The lifting arrangement can be connected or disconnected without the necessity of stopping or starting the motors, by the use of friction clutches.

With these motors 50,000 kilos. of wheat can be raised hourly, and the installation is capable of lifting 65,000 kilos. hourly, which corresponds to an excess of duty of 30 per cent.

Besides the six motors of 10 H.P., there will be installed three motors of 20 H.P. and one motor of 10 H.P. for cleansing the wheat and working the cleansing elevator.

It deserves mention that the provisional installation, which has been working with full satisfaction since February 1st, was completed, mounted, and set in action within two months.

ELECTRIC SCHEMES IN AUSTRALIA.

[FROM A CORRESPONDENT.]

I AM now in a position to inform you of three very interesting schemes concerning the utilisation of large water powers for generating electricity and conveying the current to distant places by means of alternating current transformers.

The first of these schemes is the proposal of lighting Melbourne by electricity, the power required to be taken from distant waterfalls, using the Yarra as motive power. According to a very detailed and interesting description in the Melbourne newspapers, there are two parts to this proposal. The first is the utilisation of the Evelyn tunnel at Warrandyte, a distance of only 11 miles from the Melbourne General Post Office. The hills here were at one time worked for their rich alluvial deposits, and the various tributaries of the Yarra carried no little gold into its bed. To recover such deposits a tunnel was bored through the narrow neck at the entrance to Pound's Bend, so as to divert the river water and leave the bed of the river dry. Such is the great bend of the river that a tunnel of 700 feet at this point saved a *détour* of about three miles. A dam was also constructed across the river to force the water through the tunnel, but it was soon flooded away, and the gold workings were then abandoned. But the tunnel remains intact, and the velocity of the small portion of the river water which still rushes through it impressed upon the present proprietors the immense amount of natural force awaiting utilisation. This, under improved circumstances, they now propose to use for the lighting of Melbourne. Under the name of the Melbourne Water Power Electric Company, 22 acres of land have been secured, taking in the neck of what is known as Pound's Bend, which is close to the township of Warrandyte, and 10¾ miles from Collingwood, where it is proposed to have the distributing station. A weir will be built across the river, and the tunnel enlarged so as to accommodate four-fifths of the flow of the Yarra, the right over which has been granted to the company by the Government. Its present discharge is 320 cubic feet per second during half flood, and there is a fall of 1 foot in 50 feet. But the minimum discharge of the river has been gauged at this point to be approximately 1,000 cubic feet per second. The tunnel is to be made capable of discharging 14,000 cubic feet per second, equal to the river flow at half flood, its size being increased from 15 feet by 9 feet to 18 feet by 18 feet.

At the outlet of the tunnel a breast dam will be constructed over which the water will flow into the penstock of the turbines, or horizontal water-wheels, and thence, having imparted its motive force to the turbines, will continue on its course back to the river. A discharge of 1,000 cubic feet of water per second is equal to 3,900 horse-power, and as the turbines are guaranteed to reproduce 85¼ per cent. of the gross power flowing over them, this will be equal to 3,321 horse-power net. This power will be produced at an initial cost of £10,150 only, as against the cost, for coal alone, of producing the same power in Melbourne per annum, of £20,000, apart from the cost of engines, &c. For the second or auxiliary scheme, at Wonga Park, a lease of 10 acres of land has been obtained, and it is proposed to divert the Yarra at this point, which is about five miles up from the Evelyn tunnel, by means of a channel, a weir being thrown across the river. There is a similar volume of discharge here as at the tunnel, and it will be utilised by means of the turbines in the same way. To bring the light generated by the action of the turbines upon the dynamos into the city, overland cables are to be used, and no difficulty is anticipated about this part of the business. A central distributing station will be established at Collingwood, and from this point the light will be made available to every part of the city to which the operations of the company will extend. Careful experiments show that nine 16-candle-power glow or incandescent lamps can be worked at short distances by each actual horse-power applied to the dynamos. With, however, 12 miles of conductor and a system of primary transformers at Collingwood, where the voltage would be reduced from 5,000 to 1,000; this number would be reduced to about 8. In the worst part of an average year—that is to say, in the dry summer months—the light supplied by the tunnel dynamos would supply 25,000 glow lamps, and, including the Wonga Park, light double that number.

This is, of course, the low midsummer estimate. In winter, when the light is most needed, the supply available and corresponding with the great volume of flood waters then in the river, would be multiplied several times. The winter estimate of both schemes amounts to 450,000 lamps. During the day, when there will be no call for light, the company propose to transmit electric power to the city to the extent of 800 horse-power in summer, and 2,100 horse-power in winter, for the working of machinery. Such a great scheme means the expenditure of a large amount of money, and to complete the whole of the works, including the cables to Melbourne, and the distribution appliances, it is estimated that at the outside £198,000 will be required. As, however, they will save at least £36,000 annually, which represents the cost of coal to produce a similar lighting power, the expenditure is looked upon as bound to lead to most profitable results. It is also intended, upon the diversion of the Yarra through the Evelyn tunnel, to work Pound's Bend again for its rich alluvial gold deposits. They contend there is ample room for their operations in Melbourne without interfering with the operations of the other electric companies, and, as they will be able to supply a cheap light, they will further assist in the popularisation of electric light for general use.

The second scheme is the utilisation of a large hydraulic power at Warnambool (a town in Victoria) of about 700 H.P., and situated at a distance of six miles from that town, which water-power is to be utilised by the same company for the distribution of electric light and motive-power.

The same company has bought a water-power of about 1,200 H.P. in Tasmania, which power will be distributed, in form of electrical energy, to several mining establishments, and about 150 H.P. to be utilised for the lighting of a town at a distance of $3\frac{1}{2}$ miles.

ECONOMY IN THE USE OF INCANDESCENT LAMPS.

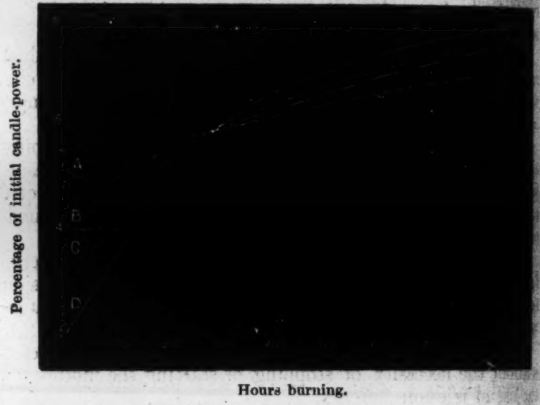
By STUART A. RUSSELL.

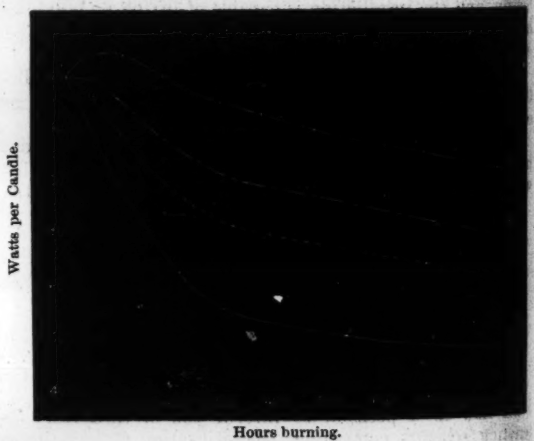
The question of what is the most economical efficiency at which to run an incandescent lamp is one that has been awaiting an answer for a long time, but very little progress seems to be made towards arriving at a satisfactory solution. This is in great measure due to the fact that life and efficiency tests on incandescent lamps require the sole use of testing apparatus for much more time than most people can spare it; but there is also another point, and that is that such work as has already been done has mostly been confined to determining the total life of the lamp, using the initial efficiency as a basis of comparison. The results of such tests are no doubt very interesting, and if the consumer is prepared to be content with knowing the smallest cost for power and lamp renewals, at which he can maintain a lamp rated at any particular candle-power, they supply all the necessary data for him to make his calculations; but it is well known that both the illuminating power and the efficiency decrease as the lamp is used, and it is most important that the relative rates of decrease, under varying conditions as to initial efficiency, should be taken into account, if the lamp user wishes to get true efficiency, *i.e.*, to obtain the greatest amount of illumination for the smallest total expenditure. In the article by Mr. Leonard, which has recently been published, he refers to this falling off of candle-power, and says that in any case where the cost of operating a 3·1 watt lamp with a life of 600 hours, and a 4 watt lamp with a life of 1,500 hours, is the same, then the 3·1 watt lamp would be the best, since the average condition of the total number of lamps on the plant would be that due to 300 hours of burning, whereas the average condition of the 4-watt lamps would be that due to 750 hours of burning; and it is evident, he says, that it will be preferable to have lamps which have averaged 300 hours of use rather than lamps that have averaged 750 hours of use.

This conclusion is, in the writer's opinion, by no means evident; indeed, it appears to be directly contrary to the results of tests that have been made in America by Prof. Nichols and Mr. Pierce. Mr. Pierce experimented on a number of lamps supplied by four different makers, and took measurements of candle-power and watts at regular intervals, the potential difference at the lamp terminals being kept constant at the volts marked on each lamp. Some of his results are shown in the following curves, in which, however, the results have been averaged for lamps of the same initial efficiency, although by different makers, instead of being given in a number of separate curves as published by Mr. Pierce.

An examination of the power curves shows that they tend more and more to become flat as the initial value of the ratio of watts to candle-power is increased, that the average efficiency over the 900 hours varies very little, and that the effect of the first 300 hours' burning on the lamps which start with a high efficiency, is to increase the ratio of watts to candle-power at such a rate as to make these lamps no better at that time than any of the others. Looking now at the curves which show the falling off of candle-power, it will be seen that this latter is very much more marked in lamps of high initial efficiency; the 3-watt lamp after 100 hours' burning giving only the same amount of light as the $4\frac{1}{2}$-watt lamp after 900 hours, and after 200 hours giving less light than the 4-watt lamp after 900 hours. This is a very important matter, as one often hears the statement that "the electric light is all right when it is new, but after it has been running for a time it does not light so well as gas." Of course the effect, as regards general illumination, is more marked in a new installation, where all the lamps show a falling off in candle-power together, than after the lamps have been renewed once or twice; but in this latter case a fresh difficulty arises, namely, that of two lamps in close proximity to one another, one may be giving twice as much light as the other. In this connection it may be well to point out that the neglect of a periodical cleaning of the lamp bulbs and globes greatly increases the inequality of light from lamps of different ages, and that lamp users might, by attending to this, materially increase the available lighting power of their lamps.

It is evident that from the point of view of true economy, any results obtained from calculations based on the initial efficiency and total life of the lamps are misleading; and that the calculations should be made by comparing the actual candle-power hours and cost of maintenance throughout the life of the lamps. Take, for example, the 8 candle-power lamp costing 45 pence, and compare two lamps, one starting at 3 watts per candle and having, say, a life of 500 hours, and the other starting at 3·65 watts per candle and having a life of 800 hours, the cost of a Board of Trade unit in both cases being 8d. According to the data furnished by the curves, the 3-watt lamp will in 500 hours give a total of 2,664 candle-power hours at an expenditure of 11,650 watt-hours, whilst the 3·65 watt lamp will in 800 hours give a total of 4,736 candle-power hours at an expenditure of 23,600 watt-hours. The cost of current will therefore be 93·2 pence and 188·8 pence respectively, to which must be added 45 pence for renewing the lamp, making the total cost of 2,664 candle-power hours 138·2 pence, or 19·28 candle-power hours for a penny for the 3-watt lamp, and of 4,736 candle-power hours 233·8 pence, or 20·26 candle-power hours for a penny for the 3·65 watt lamp. Even if the 4-watt lamp is taken with an average life of 900 hours, which is too low in comparison with the others, it comes out as the most economical, giving a total of 5,780 candle-power hours for $(232 + 45) = 277$ pence, or 20·86 candle-power





hours per penny. With a 16 candle-power lamp, also costing 45 pence, and the same price for current, the 3-watt comes out best, giving nearly one more candle-power hour for the penny than the 4-watt lamp; but, notwithstanding this advantage, it is questionable if it is the best lamp to use, owing to the fact that its illuminating power at the end of 500 hours is only 51 per cent. of the initial, and its average only 67 per cent., whilst the corresponding figures for the 4-watt lamp are 68 per cent. at the end of 900 hours, with an average of 81 per cent. The cost of the unit has been taken at the maximum allowed—viz., 8 pence—and any reduction in this will favour the lamps of lower initial efficiency; and in a similar manner, any decrease in the cost of the lamp will favour those of higher initial efficiency.

Another question that is of importance economically is that of when a lamp should, although not broken, be thrown away. Every now and then a note appears about some lamps which have had very long lives, but it is seldom that any figures are given of the candle-power and efficiency of such lamps. The writer had the opportunity of making such tests on a dozen lamps some few weeks ago, with the results shown in the table herewith; these lamps were 110-volt 16 candle-power Edison-Swan lamps, which had been on a circuit running nearly continuously for about 4 years. The actual number of hours' burning for each lamp could not be ascertained, as they were controlled separately by small switches; but the number of hours during which the circuit had been running since the lamps were fixed was known, being about 30,000 hours, and it is safe to assume that they had been at work for a very long time, as they were lighting a portion of a factory where day and night shifts were regularly employed. From voltmeter readings taken at the lamp terminals when the dynamo was giving 110 volts, that being the voltage which the engine driver had instructions to maintain, it is probable that the average working potential difference at the lamps was between 106 and 107 volts, but the tests shown below were taken with 110 legal volts at the terminals, that being the proper voltage for the lamp.

TEST ON 12 EDISON-SWAN LAMPS OF 16 CANDLE-POWER.

No. of lamp.	E.M.F.	Current.	Watts.	C.P.	Watts per C.P.
1	110	·407	44·77	3·72	12·02
2	"	·419	46·09	4·97	9·27
3	"	·476	52·36	4·82	10·87
4	"	·414	45·54	4·38	10·39
5	"	·407	44·77	3·61	12·41
6	"	·449	49·39	5·61	8·80
7	"	·402	44·22	3·22	13·74
8	"	·454	49·94	4·38	11·40
9	"	·417	45·87	4·82	9·52
10	"	·419	46·09	4·25	10·85
11	"	·456	50·16	4·25	11·81
12	"	·511	56·21	5·70	9·87
Average ...	110	·436	47·95	4·48	10·70

These tests show how uneconomically lamps may be used, through only considering the lamp renewals; and though it rarely happens that lamps can be worked under such conditions, yet the same effects in a modified form are often produced before the average life of a lamp has been reached. Consider from this point of view what should be the life of a lamp like one of those whose data are given in the curves previoursly shown. This may be done by finding at the end of each 100 hours the ratio of total candle-power hours produced to expenditure; as, for example, taking a 3-watt 16 candle-power lamp costing 45 pence, and the unit at 8 pence, the following results are obtained:—If the lamp is renewed after 100 hours, 1,456 C.P. hours are obtained for 84·2 pence, or 17·29 per penny; after 200 hours 2,640 C.P. hours for 122 pence, or 21·64 per penny; after 300 hours 3,616 C.P. hours for 159 pence, or 22·74 per penny; after 400 hours 4,496 C.P. hours for 195·4 pence, or 23·01 per penny; after 500 hours 5,328 C.P. hours for 231·4 pence, or 23·03 per penny; after 600 hours, 6,134 C.P. hours for 267·2 pence, or 22·96 per penny; after 700 hours, 6,918 C.P. hours for 303 pence, or 22·84 per penny. It will be seen, therefore, that it is economical with such lamps to renew them after 500 hours, although their average life may possibly be greater than that length of time. With lamps of less candle-power, whose behaviour is similar, the economical life will increase, since the cost of the lamp will not decrease in proportion to the rated candle-power; and in a similar manner with lamps of higher candle-power, it will pay to throw them away sooner, since the cost of renewal will not increase as fast as the candle-power. A cheaper unit will, of course, increase the economical life.

To sum up, it would appear that the correct way to treat this question of economy is first of all, having got the necessary data of efficiency and decrease of candle-power, to find what is the most economical number of hours to burn each lamp, and then to compare the lamps of different initial efficiencies, and see which gives the largest number of candle-power hours for a penny throughout its economical life. The various calculations have been, as already stated, based on data obtained from lamps of American make, since the writer is not aware of any such data having been published for lamps of English make; but though the numerical results may, and probably will, be somewhat different, the examples chosen will serve to show approximately how the best results may be obtained in this matter of economical working.

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.*

ON SOME EFFECTS OF ALTERNATING CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.

By DR. J. A. FLEMING, Member.

The full analytical treatment of the problem of the propagation of an electric current through a conductor possessing capacity and resistance is one which is by no means simple. If to this is added the consideration of the additional condition that both the line and the receiving and transmitting instruments possess self-induction, the problem in its full generality is a very complex one. For certain assumptions as to the mode of variation of the impressed electromotive force, and with other limitations, it may be said to have been solved for periodic currents; but if we consider the practical case of receiving and transmitting appliances of variable inductance, it can hardly be said that analysis enables the results of definite arrangements to be completely predicted. Fortunately, in much practical work the additional complications which arise from the simultaneous presence of capacity and self-induction in the system are negligible, but useful, and existing work is not entirely thus limited; and electrical distribution by means of transformers, alternating currents, and concentric cables forces us to regard phenomena due to the co-existence of inductance resistance and capacity in one circuit, which need interpretation, even if only so far as to enable constructive mistakes to be avoided. We have already been made aware by experience that under these circumstances unexpected effects often make their appearance, and these demand examination at this period in the history of the large-scale manufacture and distribution of electric current, to enable us to appreciate the meaning of observed facts. The object of the present paper is to gather together some of the results already arrived at, and to point out a part of the existing state of knowledge of the propagation of alternating currents in circuits in which neither the inductance nor the capacity are so small that they can be left unconsidered in their effects.

2. It will be convenient to start the inquiry by examining a typical and simple case involving simple periodic electromotive force, and inductance and capacity in the circuit. Such problems have already been treated analytically by Dr. Hopkinson; geometrically by Mr. Blakesley, Major Cardew, Mr. Kapp, myself and others.†

Let A be an alternator feeding an inductive circuit, $a\,b\,f$, of which the section $a\,b$ has inductance L and resistance R, and the section $b\,f$ has inductance l and resistance r. At b let a condenser of capacity C be inserted, and let the terminals e, d, and f of the line, condenser, and alternator be to earth.

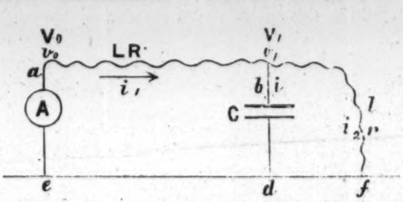


FIG. 1.

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* Paper read May 7th, 1891.

† Dr. Hopkinson's paper on "The Theory of Alternating Currents" is in the *Proceedings of the Institution of Electrical Engineers* (late *Journal of the Society of Telegraph Engineers*), for 1884, vol. xiii., p. 496. Mr. Blakesley's papers are collected in his admirable little book on "Alternating Currents."

Let v_0 be the potential at a at any instant, and v_1 that at b: and let V_0, V_1, be the maximum values of these potentials, supposed to vary harmonically. Let i_1 and i_2 be the currents at any instant in the sections of the line $a\ b$, $b\ f$, and i the current flowing into the condenser, and $I_1\ I_2\ I$, the maximum of the same. Under these circumstances we proceed to investigate what are the relative values of V_0 and V_1, or their ratio to one another. We have always,

$$i_1 = i + i_2 \qquad (1)$$

also

$$i = C\frac{d\,v_1}{d\,t} \qquad (2)$$

and

$$l\frac{d\,i_2}{d\,t} + r\,i_2 = v_1 \qquad (3)$$

but we may write, as the currents are simply periodic,

$$i_1 = I_1 \sin p\,t \qquad (4)$$

where $p = 2\,\pi\ n$, n being the frequency of the periodic current in $a\ b$, and t the time reckoned from the instant when the current in this first section is zero.

By elimination of v_1, i_1, and i from the above four equations we find easily that

$$C\,l\frac{d^2\,i_2}{d\,t^2} + C\,r\frac{d\,i_2}{d\,t} + i_2 = I_1 \sin p\,t \qquad (5)$$

Since i_2 must also be a simple periodic current, lagging in phase behind that of the current, i_1, we may take i_2 to be of the form,

$$i_2 = I_2 \sin(p\,t - \theta) \qquad (6)$$

Hence, by differentiation of (6), and substitution in (5), we arrive at

$$(1 - C\,L\,p^2)\,I_2 \sin(p\,t - \theta) + C\,r\,p^2\,I_2 \cos(p\,t - \theta) = I_1 \sin p\,t \qquad (7)$$

which, by a well-known transformation, may be put in the form,

$$I_2\sqrt{(1 - C\,l\,p^2)^2 + C^2\,r^2\,p^2}\,\sin(p\,t - \theta + \phi) = I_1 \sin p\,t \qquad (8)$$

Both sides of this equation (8) are expressions for the same thing—namely, the value of i_1—hence, equating coefficients, we have

$$\left(\frac{I_1}{I_2}\right)^2 = (1 - C\,l\,p^2)^2 + C^2\,r^2\,p^2 \qquad (9)$$

Putting $a = 1 - C\,l\,p^2$, and $b = C\,r\,p$, we have

$$\left(\frac{I_1}{I_2}\right)^2 = a^2 + b^2 \qquad (10)$$

This gives us the ratio of the maximum, or square root of the mean square values of the currents in the two sections of the line on either side of the condenser.

It is convenient next to shift the origin of the time, and take the instant when the current, i_2, is zero at a point from which to reckon the time.

Doing this we can write

$$i_2 = I_2 \sin p\,t \qquad (11)$$

and accordingly from (10)

$$i_1 = I_2\sqrt{a^2 + b^2}\,\sin(p\,t + \theta);$$

or

$$i_1 = I_2(a \sin p\,t + b \cos p\,t) \qquad (12)$$

hence

$$i_1 - i_2 = I_2(\overline{a - 1} \sin p\,t + b \cos p\,t) \qquad (13)$$

but from (1) and (2)

$$i_1 - i_2 = C\frac{d\,v_1}{d\,t};$$

$$\therefore C\frac{d\,v_1}{d\,t} = I_2(\overline{a - 1} \sin p\,t + b \cos p\,t);$$

or

$$v_1 = \frac{I_2}{C\,p}(b \sin p\,t + \overline{1 - a} \cos p\,t) \qquad (14)$$

$$\therefore V_1 = \frac{I_2}{C\,p}\sqrt{\overline{a - 1}^2 + b_2} = I_2\sqrt{r_2 + p_2\,l_2} \qquad (15)$$

We have next to find the value of V_0.

$$v_0 - v_1 = L\frac{d\,i_1}{d\,t} + R\,i_1 \qquad (16)$$

and if we substitute in (16) the value of i_1 given in (12), and of v_1 given in (14), and integrate, we arrive at

$$v_0 = I_2\left\{\left(R\,a + \frac{b}{C\,p} - L\,p\,b\right)\sin p\,t + \left(R\,b + \frac{1 - a}{C\,p} + L\,p\,a\right)\cos p\,t\right\};$$

but, since $\frac{b}{C\,p} = r$, and $\frac{1 - a}{C\,p} = p\ l$, we get by proper substitution in the above equation, and by the application of the rule for harmonic maxima, the equation,

$$V_0 = \frac{I_2}{C\,p}\sqrt{(A^2 + B^2)(a^2 + b^2) + 2\,B\,b - 2\,A\,a + 1} \qquad (17)$$

where

$$A = 1 - C\,L\,p^2; \qquad a = 1 - C\,l\,p^2;$$

$$B = C\,R\,p; \qquad b = C\,r\,p.$$

Equations (15) and (17) give us the values of the maximum or mean potentials at the generator and condenser end of the line $a\ b$. If we divide equation (17) by equation (15), we get a value for the ratio of V_0 to V_1. A little tedious process of division and substitution brings us finally to the required result, which is,

$$\frac{V_0}{V_1} = \sqrt{(A^2 + B^2) + (1 - C\,p^2)\frac{R^2 + p^2\,L^2}{r^2 + p^2\,l^2} + \frac{2\,L\,l\,p^2}{r^2 + p^2\,l^2} + \frac{2\,R\,r}{r^2 + p^2\,l^2}} \qquad (18)$$

This last equation furnishes us with the required result, viz., the ratio of the maximum or mean potentials at the ends of the inductive line $a\ b$ in terms of the coefficients of inductance, capacity and resistance.

Given V_0, it enables us to calculate V_1, and to say whether V_1 is greater than, less than, or equal to V_0.

3. Let us examine some particular cases. Suppose $r^2 + p^2\,l^2 = \infty$—that is, suppose the section of the line beyond the condenser removed—then

$$\frac{V_0}{V_1} = \sqrt{A^2 + B^2} = \sqrt{(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2} \qquad (19)$$

This reduced case was treated by Dr. Hopkinson long ago,[*] and he showed, as we can easily see, that it is possible for the ratio of V_0 to V_1 to be *less* than unity—that is, for the potential at the receiving end, or at the condenser, to be *greater* than the potential at the sending end.

It is very easy to state the conditions under which this is the case. In order that V_1 shall be greater than V_0, or that there may be a rise of pressure, we must have

$$\sqrt{(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2}$$

less than unity; hence we must have

$$(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2 < 1,$$

or

$$1 + C^2\,L^2\,p^4 - 2\,C\,L\,p^2 < 1 - C^2\,R^2\,p^2,$$

or

$$C < \frac{2\,L}{R^2 + p^2\,L^2} \qquad (20)$$

If L, R, and p are constant, the value of C which makes the ratio of V_1 to V_0 a maximum is

$$C = \frac{L}{R^2 + p^2\,L^2}.$$

Hence, if the capacity, C, of the condenser, measured in farads, is *less than* the quotient obtained by dividing twice the inductance of the line, L, measured in henrys, by the square of the impedance ($R^2 + p^2\,L^2$), we shall, under these circumstances, find a rise in pressure at the condenser end. For example, suppose the value of n or the frequency is 67, then $p = 421$, and $p^2 = 177{,}241$. If $R = 1$ ohm, and $L = 1$ henry, then $R^2 + p^2\,L^2 = 1{,}773$, and there ought to be a rise in pressure if C is greater than 112 microfarads; or, if $R = 1$ ohm, and $L = 100$ henrys, then $R^2 + p^2\,L^2 = 1{,}772{,}410{,}000$, and there ought to be a rise in pressure if C is greater than one-eighth of a microfarad. Generally speaking, the greater L, the less will be the critical value of C. For high frequencies the criterion of rise of pressure at the condenser end is

$$C < \frac{2}{L\,p^2}.$$

That is to say, the critical capacity is just twice that which will at the given periodicity nullify the inductance of the armature circuit. It is worth while to note that even if the criterion for rise of pressure at the condenser end is fulfilled by L, R, C, and p, yet, as seen from equation (18), a sufficiently small impedance ($\sqrt{r^2 + p^2\,l^2}$) in the shunt may nullify the effect and force V_1 to be less than V_0.

4. These *condenser effects*, as they may be called, are very strikingly shown when currents of high frequency are used. Quite recently, Mr. Nikola Tesla has published some interesting observations and experiments on alternating currents with the very high frequencies of 10,000 to 20,000 alternations per second, and amongst these he has described an experiment with a condenser joined across the poles of such an alternator. A machine was used giving about 20,000 alternations per second. Two bare wires about 20 feet in length were attached to the poles, and their ends connected to the terminals of a condenser. The difference of potential between parallel points on these wires was explored by a voltmeter, and it was found that the potential difference of parallel points on the wires steadily rose inch by inch from 65 volts at the terminals of the alternator to 120 volts at the terminals of the condenser; and the writer states that observations on the self-induction of the armature in its position of maximum and minimum inductance showed that the capacity which gave the greatest rise at the condenser end corresponded apparently to that which would about nullify the mean self-induction calculated from the observed maximum and minimum. This entirely corresponds to the above theoretical deduction.

5. The fact that when a condenser is thus charged by an alternating-current machine its terminal potential difference may be very much greater than that of the machine terminals, appears to have been noticed experimentally prior to the time when the simplest case was mathematically treated by Dr. Hopkinson. In the paper of the latter above referred to, it is mentioned that Dr. Muirhead had observed it experimentally. In the discussion which followed Dr. Hopkinson's paper, Mr. Blakesley dealt with the same matter in some geometrical diagrams, and Professor Ayrton mentioned that in 1878 or 1879 Mr. Munro took out a patent for the use of condensers in combination with an alternate-current machine. In any case, the experimental verification of a rise of pressure along the line leading from the machine to the condenser is complete.

6. In his book on "Alternating Currents," p. 55 (2nd edition), Mr. Blakesley has treated by his geometrical methods the case examined above, with the object of showing that the employment of a condenser in this manner in combination with a pair of inductive circuits may under certain conditions cause the current in the remote, or shunt, circuit to be greater than the current in the circuit in connection with the machine; and he shows there that a similar criterion to the one given above applies also to the relative current-strengths in the two

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[*] See *Proceedings of the Institution of Electrical Engineers* for 1884, page 513.

sections—viz., that the current I_2 in section $b\,f$ will be greater than the current I_1 in section $a\,b$ if C is less than $\frac{2\,l}{r^2 + p^2\,l^2}$.

Hence, generally, we have that the maximum or mean potential V_1, at the terminals of the condenser will be less than, equal to, or greater than the maximum or mean potential at the terminals of the machine, V_0, according as the capacity, C, of the condenser is greater than, equal to, or less than the quantity, $\frac{2\,L}{R^2 + p^2\,L^2}$, in numerical value; and also that the maximum or average current-strength in the remote, or shunt, section of the line will be less than, equal to, or greater than the maximum or mean current-strength in the section of the line near to the machine, according as the capacity, C, of the condenser is greater than, equal to, or less than the quantity, $\frac{2\,l}{r^2 + p^2\,l^2}$, in numerical value. Note that if R is measured in ohms and L in henries, C must be measured in farads.

If we look again at the equation,

$$\left(\frac{V_0}{V_1}\right)^2 = (1 - C\,L\,p^2) + C^2\,R^2\,p^2,$$

and note what are the conditions under which V_1 will be *greater* than V_0, or the pressure at the condenser end greater than the pressure at the machine end of the line, we see that it depends upon whether the right-hand expression, when worked out numerically, is a proper fraction. Since almost any capacity which occurs in practice is numerically represented by a very small fraction when the farad is the unit, if p^2 is not very great $C^2\,R^2\,p$ will nearly always in practice be a proper fraction when we insert values of C and R in farads and ohms. Hence the condition of rise of pressure will depend almost always on whether $C\,L\,p^2$ is numerically greater than 2 when C and L are measured in farads and henries; and if C is very small, either L or p must be very large to secure this result, and *vice versâ*. Hence, generally, if the inductance of the machine circuit is very large, a comparatively small capacity across its poles may give rise to a very great condenser effect; but if the inductance of the machine is small, a very large capacity will be needed to bring about the increased pressure at the terminals of the condenser.

Suppose, for instance, that a transformer is used to raise the pressure of an alternator, and that across the high-pressure terminals of the transformer is placed a condenser of capacity C. This may be either a condenser of the ordinary form, or a certain length of concentric cable insulated at the far end and having a definite capacity. Let us suppose that the high-pressure circuit of the transformer has a great many turns of wire. The mean inductance of this high-pressure coil is then the L in our formula, its resistance is our R, and p^2 is $4\,\pi^2\,n^2$, where n is the frequency of the alternator. To fix our ideas, let $n = 83 = 10{,}000$ alternations per minute, then $p^2 = 273{,}947$.

Let $R = 10$ ohms, and $L = 200$ henries—values possible to be reached in practice—then, if C is measured in microfarads, we see that $(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2$ becomes

$$\left(1 - \frac{C \times 273{,}947 \times 200}{10^6}\right)^2 + \frac{C^2\,27{,}394{,}700}{10^{12}} = (1 - 55\,C)^2 + {\cdot}00003\,C,$$

nearly.

If C is absolutely zero, the value of this quantity is unity. If C is equal to $\frac{1}{27}$th of a microfarad, this quantity is also, roughly, equal to unity. If C has any value between zero and $\frac{1}{27}$th of a microfarad—say $\frac{1}{50}$th of a microfarad—then, since $\left(1 - \frac{55}{50}\right)^2 + {\cdot}00003\,\frac{1}{50} = {\cdot}01$, nearly, we see that the ratio of V_0^2 to V_1^2 will be 1 to 100, or V_1 will be ten times V_0. Hence it is obvious there is a narrow range of capacity within which the pressure at the condenser terminals may be enormously increased over that at the machine terminals; but if the capacity is altered so as to take it outside these critical limits, the so-called resonance effects will vanish.

The best way to see how the value of V_1, or the condenser potential, varies with variation of the capacity, other quantities being constant, is to plot the equation,

$$V_1 = \frac{V_0}{\sqrt{(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2}},$$

or—which comes to the same thing, and is simpler to plot—the equation,

$$y = \frac{1}{\sqrt{(1 - x)^2 + x^2}}.$$

This has been done in fig. 2, and a curve representing the variation of V_1 in terms of C, or of the condenser plate P.D. in terms of its capacity, supposed variable, is there drawn, on the assumption that V_0, L, R, and p^2 have certain constant values. We see that the curve ordinate has a maximum corresponding to a certain capacity, and that beyond that point increase in capacity continuously diminishes the condenser plate P.D.

The condenser effect will be at a maximum when C and L have such magnitudes that $C\,L\,p^2$ is unity, and C has at the same time a small value. In this case V_1 may be hundreds or thousands of times greater than V_0. In testing condensers with alternating current machines, it is very important not to have that particular critical relation between C, p, and L, or the capacity, frequency, and inductance of the machine, which will bring about the resonance effect, or else the testing process may be a destructive process as far as the condenser is concerned.

8. Quite similarly, we can show that if the capacity of the condenser is fixed, there is a certain range of inductance of the circuit of the alternator within which the resonance effect takes place. For example, let $C = {\cdot}1$ microfarad, as before, $p^2 = 273{,}947$, and $R = 10$ ohms, then for the ratio of V_0^2 to V_1^2 we have the value,

$$\left(1 - \frac{273{,}947\ L}{10^7}\right)^2 + \frac{273{,}947 \times 100}{10^8} = (1 - {\cdot}027\,L)^2 + {\cdot}27.$$

If $L = 0$, this ratio is greater than unity; if $L = 74$, the ratio is again greater than unity; but for values of L between 0 and 74, the ratio is less than unity. In other words, within these limits of the inductance the pressure at the poles of the condenser is raised.

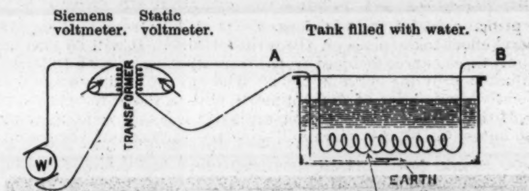
FIG. 2.

Curve plotted from the equation, $y = \frac{1}{\sqrt{(1 - x)^2 + x^2}}$,

or $V_1 = \frac{V_0}{\sqrt{(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2}}$.

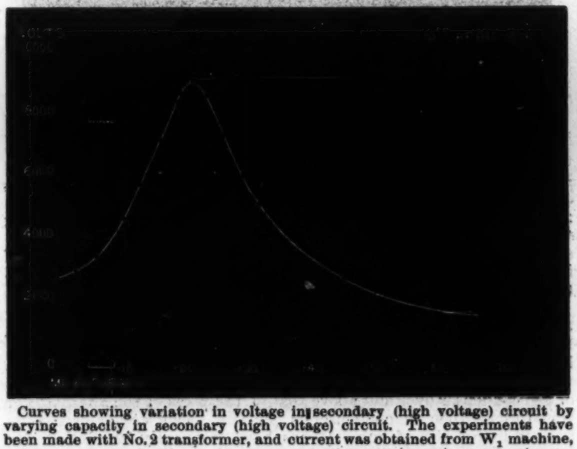
FIG. 2.

The above theory is shown to be confirmed in its general character by the results of some highly interesting experiments, made more than a year ago (April 10th, 1890), at the works of Messrs. Siemens Bros., which Mr. Alexander Siemens has sent to me. A Siemens W_1 alternator was kept running at a constant speed of 750 revolutions, and the exciting current was also kept constant. The current from this was sent into the thick wire coil of a No. 2 transformer. The terminals of the fine wire circuit were connected to various lengths of single conductor cable, having gutta-percha insulation and immersed in a tank; the cables being insulated at the far ends, and forming thus a condenser attached to the secondary of the transformer (see fig. 3). The pressure was measured at the terminals of the machine, and at the terminals of the transformer on the secondary, or condenser, side. The experiments consisted in varying the length of the cable used so as to vary the capacity, and in observing the pressure at the two sides of the transformer whilst the dynamo was kept running at constant speed and excitation. The results are embodied in the following series of interesting curves. The horizontal distances in the diagrams represent the various capacities of the open circuit cables or condenser attached to the terminals of the secondary of



Arrangement of alternator, transformer, and cable in experiments made at Messrs. Siemens's works.

FIG. 3.

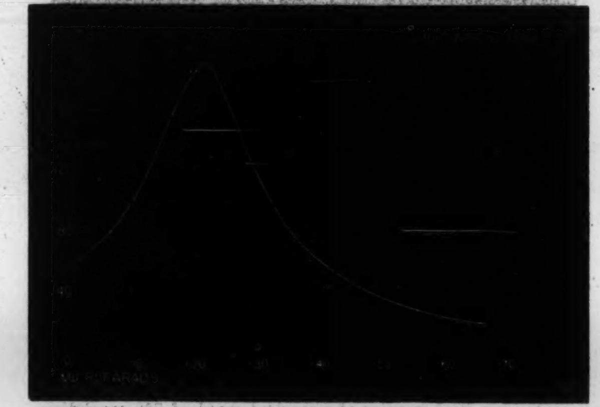


Curves showing variation in voltage in secondary (high voltage) circuit by varying capacity in secondary (high voltage) circuit. The experiments have been made with No. 2 transformer, and current was obtained from W_1 machine, frequency being 100 ∿. The exciting current was constant, and the alternator was running at 750 revolutions during all the experiments.

FIG. 4.

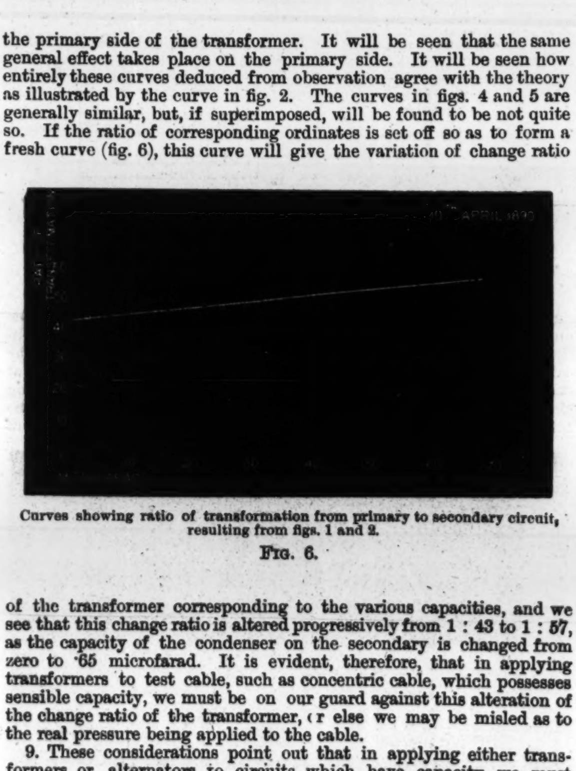
the transformer. The vertical ordinates in fig. 4 represent the observed P.D. of the two surfaces of this condenser—that is, the P.D. at the secondary terminals of the transformer.

It will be seen from fig. 4 that when the capacity is zero this P.D. was 2,500 volts. As the length of cable was increased continuously, this P.D. rose up to 8,500 volts, corresponding to a capacity of ·2 microfarad, and then fell again to 2,500 volts, at a capacity of ·45 microfarad. Hence, corresponding to a certain capacity—viz., ·2 microfarad—the pressure is multiplied about 3½ times, and there is a certain narrow range of capacity over which this exaltation of pressure takes place. At and beyond ·45 microfarad capacity, the presence of the condenser reduces the normal pressure continuously. The pressure on the primary side of the transformer is also increased, as shown in the curve given in fig. 5, which represents a series of similar pressure observations taken on the primary side of the transformer. It will be seen that the same general effect takes place on the primary side. It will be seen how entirely these curves deduced from observation agree with the theory as illustrated by the curve in fig. 2. The curves in figs. 4 and 5 are generally similar, but, if superimposed, will be found to be not quite so. If the ratio of corresponding ordinates is set off so as to form a fresh curve (fig. 6), this curve will give the variation of change ratio of the transformer corresponding to the various capacities, and we see that this change ratio is altered progressively from 1 : 43 to 1 : 57, as the capacity of the condenser on the secondary is changed from zero to ·65 microfarad. It is evident, therefore, that in applying transformers to test cable, such as concentric cable, which possesses sensible capacity, we must be on our guard against this alteration of the change ratio of the transformer, or else we may be misled as to the real pressure being applied to the cable.



Curves showing variation in voltage in primary (low voltage) circuit by varying capacity in secondary (high voltage) circuit. The experiments have been made with No. 2 transformer, and current was obtained from W_1 machine, frequency being 100 ∿. The exciting current was constant, and the alternator was running at 750 revolutions during all the experiments.

FIG. 5.



Curves showing ratio of transformation from primary to secondary circuit, resulting from figs. 1 and 2.

FIG. 6.

9. These considerations point out that in applying either transformers or alternators to circuits which have capacity, we must have regard to the fact that for certain critical values of the inductance and the capacity for given frequencies, there may be a very considerable increase in the potential difference of the two sides of the condenser over and above that of the poles of the alternator or transformer when no condenser is present. Such effects have been noticed in practice of late. It has been frequently found that if a transformer which gives on its open secondary circuit a certain P.D. is applied to test the insulation of a length of concentric cable by connecting its terminals to the two conductors, the far ends of the cable being insulated, under some circumstances an increased P.D. is observed between the free ends of the cable over and above that at the terminals of the transformer when the cable is not connected to it. When transformers have been employed to test the insulation of armatures of high-pressure alternators, it has been noticed that under some circumstances large snapping sparks will jump off over air distances which could not possibly permit discharges at the actual P.D. of the secondary terminals of the transformer so used when unconnected with any such body having capacity.

In employing an alternator or transformer to test insulation between two opposed conductors, or in any way in which the opposed terminals gain capacity, it is necessary to be on the watch for this possible rise of pressure, and not to infer, because a transformer gives, say, 2,000 volts on open circuit between its poles when measured with an electrostatic voltmeter, that therefore this is the measure of the pressure which is being applied to a dielectric which forms the insulator of a condenser joined in across the poles of that transformer.

I am not at all sure that under some circumstances errors may not be committed in the mere use of an electrostatic voltmeter to measure P.D. between the poles of an alternator or a transformer, if that voltmeter happens to possess a certain capacity in relation to the inductance of the circuit in which it is joined in parallel.

10. It is easy to treat in the foregoing manner another case slightly more complicated.

Let the inductive line $a\,b\,g\,f$ (fig. 7) be divided into three sections, $a\,b$ and $b\,g$ having each resistance R and inductance L, and the section

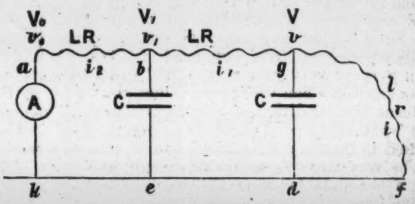


FIG. 7.

$g\,f$ having r and l for similar quantities. Let condensers of capacity C be inserted in b and g. If v and v_1 are the potentials at any instant of the condenser terminals, and i, i_1, and i_2 the instantaneous currents in the sections of the line, and I, I_1, and I_2 the maximum values of these periodic currents, it is not difficult to show, with our former notation, that

$$v_1 = \frac{I}{C\,p}\Big((B\,a + A\,b)\sin p\,t + (B\,b - A\,a + 1)\cos p\,t\Big) \qquad (21)$$

but

$$i_2 = i_1 + C\,\frac{d\,v_1}{d\,t},$$

and

$$i_1 = I\,(a \sin p\,t + b \cos p\,t) \qquad (22)$$

by (12). Hence we have,

$$i_2 = I\,\{(A\,a - B\,b + a - 1)\sin p\,t + (B\,a + A\,b + b)\cos p\,t\} \qquad (23)$$

from which we deduce that the ratio of the maximum currents, I_2 and I_1, in the first and second sections of the line is given by the equation,

$$I_2 = I\sqrt{(\overline{A + 1}^2 + B^2)(a^2 + b^2) + a\,\overline{b\,A - B} - 2\,a\,\overline{A + 1} + 2\,B\,b + 1} \qquad (24)$$

and in like manner the ratio of the maximum values of the potentials V_0 and V_1 can be obtained.

It is possible also to show that for certain critical values of L, C, and R, the potentials V_0, V_1, and V, at the terminals of the alternator and at those of the condensers, progressively increase, as well as the currents in the section of the line. Cases of this kind, beyond a single condenser, are best treated as Mr. Blakesley has done—by geometrical methods.

11. In the limited case of a condenser charged by an alternating electromotive force through an inductive circuit, we may arrive at a direct analytical solution of the relation between the coefficients of induction and capacity of the system and the mean square of the charging current, and of the potential difference at the poles of the condenser or at those of the alternator, as follows:—As before, let V_0 and v_0 stand for the maximum and instantaneous values of the potential difference at the poles of the alternator; let V^1 and v_1 be the same quantities at the terminals of the condenser; and let I and i be the same for the current flowing into the condenser having a capacity C, whilst the line connecting the condenser with the alternator has an inductance L and a resistance R. We have then, by fundamental equations, the following relations:—

$$L\,\frac{d\,i}{d\,t} + R\,i = v_0 - v_1 \qquad (25)$$

$$i = C\,\frac{d\,v_1}{d\,t} \qquad (26)$$

Also, let $v_0 = V_0 \sin p\,t$, and hence

$$i = I \sin(p\,t + \theta),$$

where θ is the angle of lag of current behind the impressed electromotive force.

Eliminating v_1 from the above equations, we have,

$$L\,\frac{d^2\,i}{d\,t^2} + R\,\frac{d\,i}{d\,t} + \frac{i}{C} = p\,V_0 \cos p\,t \qquad (27)$$

or since, for simple periodic currents, $-\,p^2 = \frac{d^2}{d\,t^2}$, we have,

$$\frac{d\,i}{d\,t} + \frac{1 - C\,L\,p^2}{C\,R}\,i = \frac{p\,V_0}{R}\cos p\,t \qquad (28)$$

This equation is of the form,

$$\frac{d\,i}{d\,t} + \text{P}\,i = \text{Q} \cos p\,t,$$

the solution of which is known to be

$$i = \frac{\text{Q P}}{\text{P}^2 + p^2} \cos p\,t + \frac{\text{Q}\,p}{\text{P}^2 + p^2} \sin p\,t;$$

and an easy transformation gives us, therefore, the solution for the particular case in hand as

$$i = \frac{(1 - \text{C L}\,p^2) \cos p\,t + \text{C R}\,p \sin p\,t}{(1 - \text{C L}\,p^2)^2 + \text{C}^2\,\text{R}^2\,p^2}\,\text{C}\,p\,\text{V}_0 \qquad (29)$$

This can be written also,

$$i = \frac{\text{C}\,p\,\text{V}_0}{\sqrt{(1 - \text{C L}\,p^2)^2 + \text{C}^2\,\text{R}^2\,p^2}} \sin (p\,t - \phi) \qquad (30)$$

and the maximum value of i, viz., I, is, therefore,

$$\text{I} = \frac{\text{C}\,p}{\sqrt{(1 - \text{C L}\,p^2)^2 + \text{C}^2\,\text{R}^2\,p^2}}\,\text{V}_0 \qquad (31)$$

This gives us the mean square, or dynamometer, value of the current, I, flowing into the condenser in terms of the mean square value of the potential difference of the poles of the alternator and the co-efficients C, L, R, and p. If $\text{C L}\,p^2 = 1$, then the value of I reduces to $\frac{\text{V}_0}{\text{R}}$; in other words, for this particular value of the relation between the inductance and the capacity the whole system of inductive charging line and condenser acts as if it were a non-inductive conductor of resistance R.

We see also that this equation (31) can be made use of to determine L from observed values of I_1, V_0, C, R, and p, or else C when L is known. The value of the mean inductance of the line is given by the equation,

$$\text{L} = \left(\frac{1}{\text{C}\,p^2} - \frac{1}{p}\sqrt{\frac{\text{V}_0^2}{\text{I}^2} - \text{R}^2}\right) \qquad (32)$$

which gives L in terms of observable quantities.

The current at any instant flowing across the dielectric of the cable may be spoken of as the *condenser current*. It is always in magnitude equal to the product of the capacity of the condenser and the time rate of change of the mean potential difference, v_1, of its surfaces. It follows that, in the case of simple periodic currents, the square root of the mean square of this current, I, which is what we measure with a dynamometer, is equal to the product of the square root of the mean square of the condenser plate potential difference, V_1, and the quantity, C p, where C is the capacity of the condenser, and p, as usual, is $2\,\pi$ times the frequency, or $\text{I} = \text{C}\,p\,\text{V}_1$. This follows at once from equations (19) and (31). The value of the potential difference at the terminals of the condenser, as measured, say, by an electrostatic voltmeter, is therefore determined by the magnitude of the condenser current flowing into it, as measured by a dynamometer when the frequency of the current is known.

(*To be continued.*)

REMARKS ON INDUCTION IN MULTIPLE CORE CABLES.

By P. CHR. DRESING and K. GULSTAD, of the Great Northern Telegraph Company.

HAVING been engaged for some time in investigating the inductive effect between the cores in a two and three-core cable, with a view of finding some means of diminishing or neutralising the disturbance from core to core, we have had occasion to carry out a number of experiments in connection therewith, which, we hope, will prove of interest to the readers of this paper. We also think that the result of our work is such that it may, to some extent, throw light on the disputed question, whether one mainly has to do battle with electrostatic or electro-magnetic (dynamic) induction between wires suspended on the same poles or cores in the same cable.

Several experimenters have been at work from time to time, and the subject has been ventilated from several points of view; but it would appear that the *electro-magnetic* effect has been considered the principal one, and until lately, when Mr. J. J. Carty published his paper, "A New Work of Telephone Induction" (the REVIEW, December, 1889), and "Inductive Disturbances in Telephone Circuits" (the REVIEW, March, 1891), very little was heard of the *electro-static* induction between wire and wire. All our experiments which relate more especially to cores and cables prove beyond doubt that the electrostatic effect is by far the most important; we may say that it is in reality the one felt in practice, and the one which has to be compensated for in some way or other. As the difference between the two kinds has been fully explained by Mr. W. H. Preece, F.R.S., Prof. Ayrton, F.R.S. (the latter has also given a formula for calculating the value of each), and others, we don't intend to enlarge further on the subject. Suffice it to point out here that a current due to electro-magnetic induction has the same direction throughout the secondary wire, whereas electrostatic induction causes a current of opposite direction at each end of the secondary wire.

In figs. 1 and 2, where A is the primary and B the secondary wire, the arrows in 1 show the dynamic, and in 2 the static effect when currents are sent from the battery at A. It is also evident that in B, fig. 2, there is a point which is neutral, and where no current is felt.

FIG. 1.

FIG. 2.

As a matter of fact, all the phenomena as represented above will not appear in multiple core cables of considerable length, simply because the inductive capacity of the secondary core will destroy the relatively weak inductive impulse long before it reaches the distant end, and also because the primary current is weak at that end compared to its first rush into the core at the near end. The consequence of this is that the disturbance in the neighbouring wire, caused by induction, even when very delicate instruments are employed, is of no importance whatever when receiving at the same end of both cores simultaneously; but the very moment that A *sends* while B *receives*, great interference at once occurs between the cores, and the signals on B's instrument become distorted, until proper means of counteracting and neutralising the induction are introduced. We shall treat of these later on.

In order to determine whether this induction is dynamic, and due to the powerful charges and discharges of the current in the primary wire, we made the following experiment with an artificial two-core cable, as shown in fig. 3, where A and B represent the conductors prepared of strips of tinfoil; a and b are sheets of tinfoil, separated from A and B by paraffin paper.

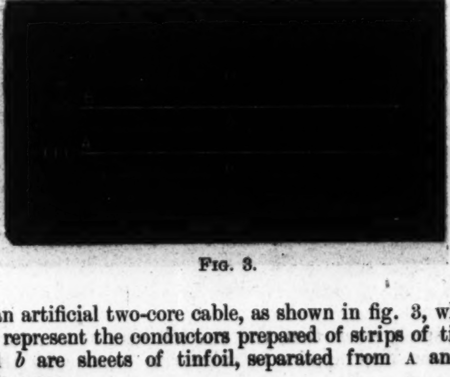


FIG. 3.

By making or breaking the current in A, no sound whatever could be heard in the telephone, T; the weak dynamic effect could not be detected, and no other induction is possible in this case.

The arrangement was altered, and connections were made as shown in fig. 4, viz., A and B got the same return wire. The telephone repeated now every manipulation of the battery key. The reason for this might be explained by saying that a minute part of the current found its way through B instead of through the return wire. This latter had, however, no appreciable resistance, and a very sensitive mirror galvanometer gave no deflection. But to make quite sure, and at the same time to prove that the induction was electrostatic in its nature, we connected *a* and *b* to the return wire by means of a copper wire (the dotted line). The sound emitted from the telephone ceased immediately, because the static induction between A and B was screened by the sheets, *a* and *b*. A and B were next insulated, as shown in fig. 5, which in reality means that the artificial cable was replaced by a condenser. In this way the inductive action was considerably increased, and a galvanometer could now easily take the place of the telephone.

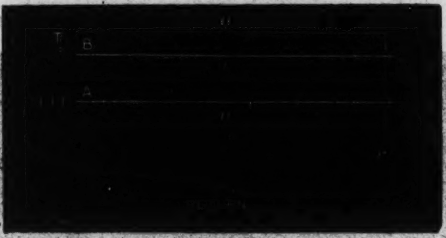
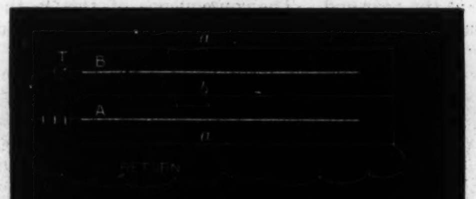


FIG. 4.

From the above we conclude that the principal induction felt in multiple core cables must be electrostatic, and if it be said that the distance between the cores in a real cable is much greater than in an artificial one, and that the conditions are different, we need only refer to the induction between wire and wire in telephone cables, where each individual core is surrounded by tin foil, electrically connected throughout and with the earth. How could one possibly screen effectively the induction between such two conductors, if it were a question of dynamic induction, which could only be remedied by passing the return wire between the inducing (primary) and the induced (secondary) wire; and no one would surely assert that the tin foil acts as a return wire. The same view applies to submarine cables with three, or more, cores, and as it is a fact easily demonstrated, that the induction between two of the cores is considerably reduced when the third is put to earth, we consider that this would be quite impossible if it were a dynamic effect.

FIG. 5.



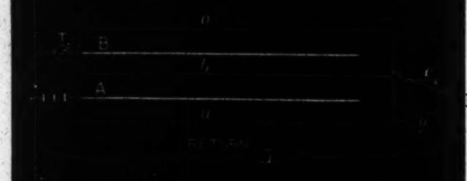


FIG. 6.

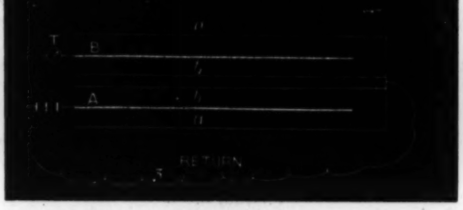


FIG. 7.

We now come to the question as to how it is possible that electrostatic induction can take place between cores submerged in water and surrounded by the sea.

The following experiment was made (fig. 6):—*a* and *b* were connected by *c* with a return wire, *z*; *x* and *y* are short pieces of wire connecting *a* and *b* with *z*. In B a telephone was placed, the battery had an E.M.F. of about 90 volts, and the condenser a capacity of about ·17 microfarad for one of the conductors, A or B. On closing or opening the battery no sound was heard in the telephone, neither was the galvanometer affected, although it was very sensitive and capable of showing induction representing about $\frac{1}{20000}$th of the capacity of A or B. The screening effect of *a* and *b* was very perfect indeed under these circumstances, but as soon as *x*, *y*, and *z* —more especially *z*—had any appreciable resistance, even a fraction of an ohm, the telephone emitted a sound whenever the battery was applied; and when *z* was equal to some hundred ohms the galvanometer was deflected also. From this it appears proved that whenever there is any, even ever so small, resistance in the earth connection, induction can be traced from core to core.

To explain this, we altered the connections in fig. 6 a little by removing the resistances *x* and *y*, *z* being again the resistance of the return wire as before, and for simplicity's sake, we made *b two* sheets of tinfoil (fig. 7). By manipulating the battery key the following now occurs:—The inductance in *z* will for some very short time retard the charging or discharging current through it, and the consequence will be that B is charged momentarily through the tinfoil sheets, *a* and *b* (*vide* "Static Induction," by K. Gulstad, C.E.). This induction does in fact appear in the interval that elapses from the moment of inductive action between the cores, until this effect can be equalised through the earth, or perhaps better between the iron wires and the outside of the cores.

It is very instructive to observe this induction on a mirror galvanometer. The spot of light moves at first sluggishly, comparatively speaking, for the charging current, and being very suddenly stopped when the discharge passes through the resistance gets a blurring appearance. What is it that causes the resistance that gives rise to this inductive effect; where is the resistance situated, and how great is it? These are questions which we cannot answer satisfactorily, as we have never had opportunity of testing a multiple core cable since we commenced these investigations, but we hope to be able to offer our readers an explanation that seems feasible.

Our view is this, that the resistance in the earth connection is partly of an electrolytic nature, and that it consequently is situated between the cores and the iron wires. Different circumstances seem to point to this, more especially the fact that the induction varies a good deal in strength and appearance, according as the copper or the zinc pole of the battery be connected with A in the case when Z is representing water. From this it would also appear that a charging current, like any other current, must overcome a certain inductance, caused by momentary polarisation; we may here refer to Sir William Thomson's experiments with semi-conductors, amongst which water in certain respects must be included, and where he points out that these semi-conductors after a little time only are able to act as conductors for static electricity. It may also be of interest to quote Mr. Latimer Clark's words in reference to the effect of mutual induction between cores in submarine cables—*vide*, the Society of Telegraph Engineers' *Journal*, Vol. iv., 1875:—

"It is true that in the Wexford cable, with instruments of the most sensitive kind, I have witnessed a sensible induction from wire to wire. That current, I imagine, was caused in the manner I have indicated: that the sudden positive electrification of one of the wires threw off a small quantity of positive electricity from its exterior, and that electricity, before it could distribute itself from the cable into the sea would momentarily raise the tension of the whole core of the cable, and cause an inductive discharge."

In another issue of the REVIEW we hope to explain other causes for the static induction between cores in multiple core cables, and also to describe the means by which the problem of overcoming these disturbances has been solved.

Jerry Builders and Lights.—A contemporary, in referring to a certain exhibition in its last issue, states that the Town and County Electric Light Company showed "primary batteries and incandescent lamps for lighting up private houses that will last three months without attention." This is distinctly a libel on jerry builders, whose houses generally last longer than three months.

THE DEPTFORD CENTRAL STATION.

There are probably few undertakings exciting greater interest at the present moment than the Deptford central station. This is reasonable, for since electric light was first used it is the largest and most important scheme that has been proposed. Mr. Ferranti's plan of generating and transmitting high pressure currents is too well-known to need recapitulation here. It must be said, however, that the work has been executed with a boldness that is startling, and we cannot withhold praise from the manner in which almost insurmountable obstacles have been overcome. But Mr. Ferranti had a "free" hand, and was backed up by a fearless and confident body of directors, whose downright honesty of purpose, despite our adverse criticism, we have never impeached. If success was ever deserved it is in the case of Mr. Ferranti and the London Electric Supply Corporation.

Deptford central station is conveniently situate at the riverside near Greenwich Hospital. It is the generating station of Mr. Ferranti's system. Here the large currents are generated and transmitted to the four distributing stations in London, of which the Grosvenor and Trafalgar only are at present in working order. The Pimlico and Blackfriars are in course of construction.

In this article it is intended, with the aid of illustrations, to give some slight notion of what the Deptford station is like. It must be understood, however, that it is by no means in a finished state, for, as will be noted elsewhere, the great 10,000 H.P. dynamos are not yet completed, and probably months will elapse before they are ready. Our readers, however, will be able from the following particulars to appreciate the greatness of the concern.

The station is a large building of 210 feet in length and 195 feet in breadth, the height of the main building is 100 feet, and chimney shafts 150. The overhead travellers, the huge planing machines and lathes, give one more the impression of a big workshop than a generating station. This is occasioned by the fact that the whole of the plant is made on the premises, a matter with which we will deal later.

The two large dynamos shown in the illustration are of 1,500 H.P. and generate current at 10,000 volts. The diameter of each armature is 13 feet, and the height of the machine from the bed plate 14 feet 6 inches. Each machine possesses 48 armature bobbins, which are copper strips wound on a core of insulated brass strips, and connected in pairs. New ones can be replaced on the armatures in a few minutes, a characteristic which is found in all the Ferranti dynamos. On the faces of the field magnets are fixed two ebonite caps fastened one inside the other with Ferranti compound. Each of these caps is tested to 20,000 volts, they thus prevent sparking from the armature to the frame of the machine.

Special attention has been paid to the effective lubrication of all parts of the machinery. At the end of the shaft of each 1,500 H.P. dynamo is a double set of pumping gear, which, drawing the oil from tanks underneath forces it into the bottom of the bearings, the oil afterwards passing through a filter back into the tank. A hollow chamber is fixed round the bearings of the dynamos through which cold water circulates freely.

By means of special machinery the field-magnet frames of the dynamo can be drawn back for cleaning in less than ten minutes. The exciting machines (Allen & Kapp dynamos) are placed at the rear of the large dynamos; they are of slow speed, 200 revolutions, 50 volts, and 400 ampères each. By means of special switches they can be connected to any of the dynamos, or, run in parallel, ampèremeters and voltmeters on each machine indicating the exact state of each exciter.

It may be a fit period to mention that all machines are now run in parallel. Formerly when changing the load at the Grosvenor from one dynamo to the other the lights blinked, which caused customers to complain. Since, however, running in parallel, the load is transferred without the least flicker.

We give a front view of the engines driving the large dynamos. They are of 1,500 H.P., and, as will be seen, are of the vertical marine Corliss type, made by Hicks Hargreaves & Co., Bolton. The driving power is transmitted by 40 5-inch ropes on a flywheel of 22 feet diameter, weighing 60 tons. The stroke of the engines is 4 feet. The low pressure cylinder measures 56 inches, the high pressure measuring 28. A special valve gear is employed on these engines; and by means of a wire rope the man in charge of the switchboard can open or close the valve at his pleasure. Swivel bearings are employed on all the dynamos and engines.

Although the corporation intended that the Grosvenor station was ultimately to be a distributing centre, current was generated there for some time. Owing, however, to the Courts issuing an injunction, the generating plant was stopped and removed to Deptford. This is shown in one of the illustrations, and is driven by two new 700 H.P. engines. The two dynamos of 625 H.P. are of slow speed, and each gives a pressure of 2,500 volts, which is converted by four 150 H.P. transformers to 10,000 volts. A Siemens exciter is used to each dynamo, a small Kapp exciter being available in case of accident. As in the other dynamos a special opening gear is attached—in this case worked by hand—one man dividing the parts in five minutes.

The engines are fitted with Corliss valves, with high and low pressure cylinders built in tandem. The diameter of the flywheel, weighing 35 tons, is 24 feet, 17 ropes driving the dynamos. As in all other parts of the machinery, swivel bearings and brasses are fitted, and all bearings are lined with white metal.

The switchboard, indistinctly seen in the illustration, is placed upon a specially insulated platform. Here the current from the four dynamos is brought and passes through ampèremeters, and then, by a switch with a three ft. break, on to the omnibus mains, which are connected with the London mains. Each of the 1,500 H.P. dynamos is connected in the same fashion, so that all may be at once placed in parallel. A separate ampèremeter on each London main indicates the amount of current passing through it.

The resistances for regulating the voltage are placed between the foundations of the engines and are worked by ebonite tubes running in slides. The fuses were originally placed in porcelain tubes, but these are being replaced by specially tempered glass, which are of greater convenience, as the exact state of the fuse is then seen.

The boiler house contains twenty-four 500-horse-power tubular boilers divided into four batteries of six boilers each. It is intended to place on the top an additional twenty-four, divided in a similar manner. This space at present is occupied by a tank which holds 800,000 gallons of water. Underneath the boilers is placed a forced draught engine to facilitate making steam rapidly in the case of a foggy day.

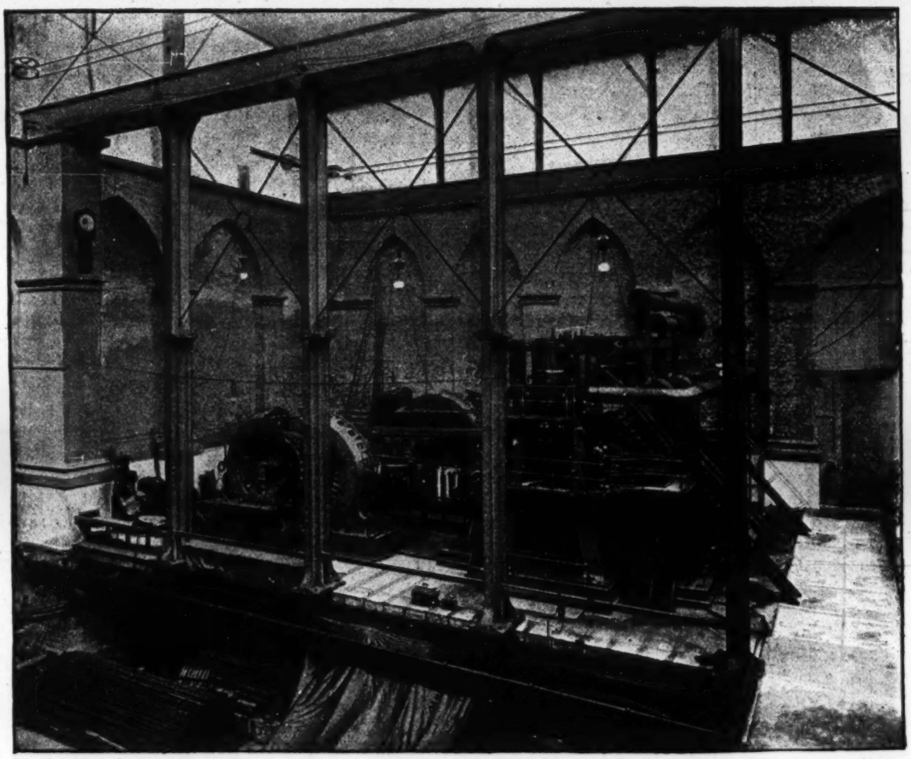
The most novel and curious of the illustrations is an armature ring for one of the 10,000 horse-power dynamos. Lying on the ground it measures thirty-five feet in diameter, it is made of cast iron in eleven pieces, and is to be fastened to the dynamo shaft by cast iron arms or spokes, each of which will be in turn secured to the shaft by a double milled steel ring shrunk on, whilst as an additional security 22 solid steel bolts, 6 inches diameter, each weighing when finished 12 cwt., passing through the outside of the armature ring, screw direct into a steel ring mounted round the centre of the dynamo shaft.

The armature and shaft when completed will weigh 225 tons, and the field-magnets 350 tons more. This is exclusive of the massive bed plate on which both the engines and field magnets will stand. One 5,000 H.P. engine is to be fixed at each end of the dynamo shaft; the armature thus being in the centre, and taking the place of the ordinary flywheel, which is entirely dispensed with; the bobbin holders are fixed in the same way as on the 1,250 machines, 132 coils being used. It may be mentioned here that five dynamos of this type, each supplying 200,000 lights, are to be built.

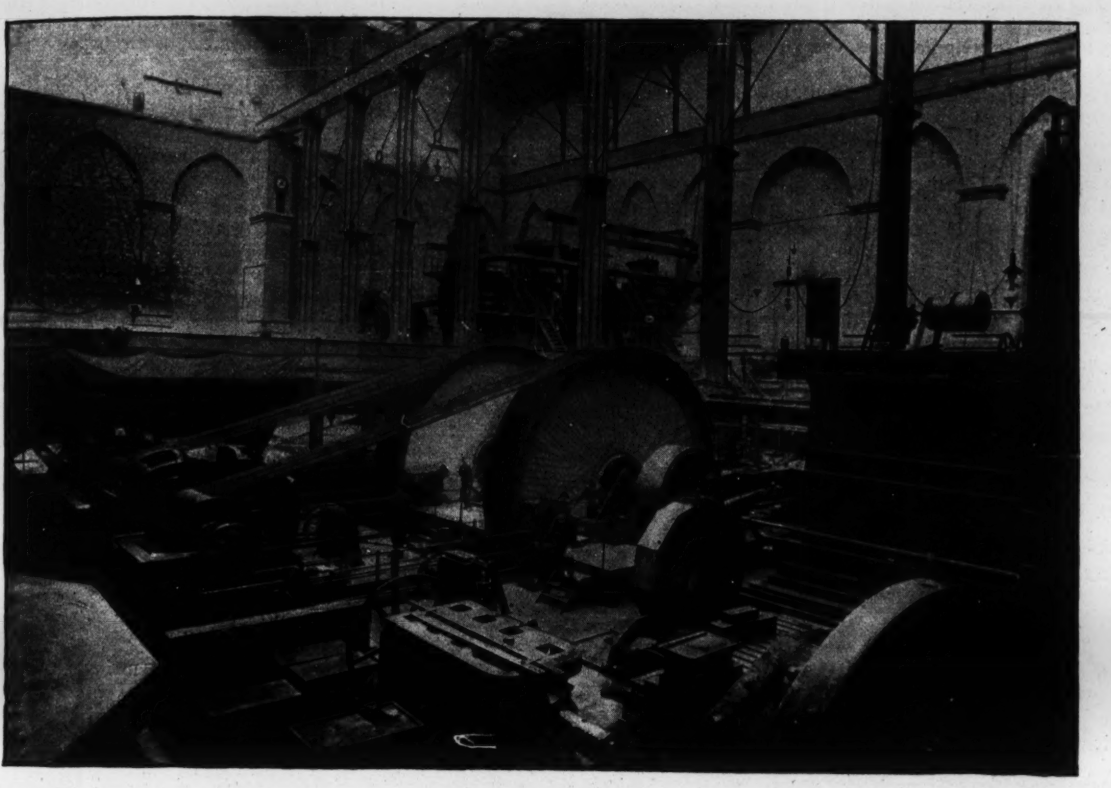
To give a slight idea of the extraordinary size of the engines to be employed for driving, the measurement from the ground to the top of the high pressure cylinder is to be 48 feet. The over-all dimension of the dynamo is 45 feet, and of this 16 feet is below the floor level. Yet, in spite of the colossal proportions, it is said the dynamos will be so easy of manipulation that they can be drawn apart for cleaning in less than five minutes.

To the left of the armature ring may be seen one of the finished shafts, which before turning weighed 30 tons, it now weighs about 20 tons, the diameter of the centre part measuring three feet; and there is a 12-inch hole from end to end of the shaft. It may here be mentioned that the steel

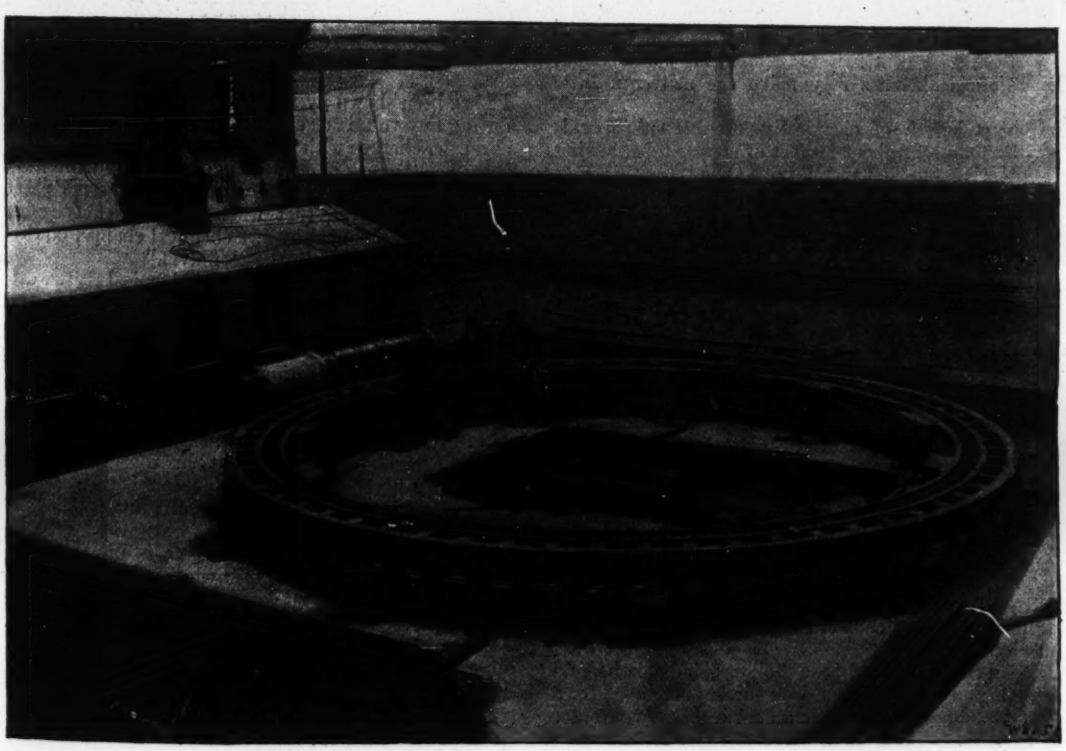
FRONT VIEW OF VERTICAL ENGINES DRIVING 1,250 H.P. DYNAMOS.



1,250 H.P. DYNAMOS (OPENED).



Old Grosvenor Dynamos.



Armature Ring for 10,000 H.P. Dynamos.

ingot for this when cast weighed 75 tons, and was the largest ever made in Scotland.

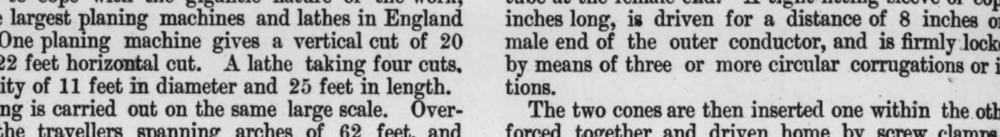
The Deptford central station differs from almost all other generating stations from the fact that, with the exception of the bare castings and engines, every part of the work is done on the premises. The turning of the shafts and crank pins, the fitting together of the dynamos, the making of the conductors, all are carried out under one active supervision.

In order to cope with the gigantic nature of the work, some of the largest planing machines and lathes in England are used. One planing machine gives a vertical cut of 20 feet and a 22 feet horizontal cut. A lathe taking four cuts, has a capacity of 11 feet in diameter and 25 feet in length.

Everything is carried out on the same large scale. Overhead are the travellers spanning arches of 62 feet, and capable of lifting 50 tons and 25 tons respectively. On the wharf is a 50-ton crane, and two 10-ton locomotive cranes.

In the making and laying of the conductors perhaps the greatest difficulties have been met. The work being new, it was necessary to specially train even the most experienced of cable hands.

How well the work has been done under Mr. Ferranti's supervision may be shown by the fact that between Deptford and London the actual measured resistance of each main was found to be 2·20 ohms, while the calculated resistance of a length of copper of that section was 2·16 ohms, thus showing that the resistance of some 2,000 double joints in each main is inappreciable. Each of the four cables gave identically the same results.



If further proof is necessary it may be stated that since February 10th these mains have been working most successfully at a daily pressure of 10,000 volts, as since that date the whole of the supply of current to the London Electric Supply Corporation has been transmitted at that pressure from Deptford to London.

It must therefore be acknowledged that up to now Mr. Ferranti has been perfectly successful with his cables.

We described in a recent issue the methods of construction, but the subjoined sketches may make the matter a little clearer:—

A continuous length of chemically-pure brown paper is rolled on to a length of about 20 feet of copper tube, having the desired sectional area of metal, until the proper thickness of insulation is obtained.

The paper is saturated while it is being wound on with a special composition (consisting mainly of ozokerite or earth wax) in a melted state, which sets very quickly.

The paper thus treated forms the insulating material between the inner tube and the outer tube, which is then slipped on and drawn down through a die, tightly compressing it on to the insulator. The tubes are of the same length and sectional area.

The outer tube is then covered in the same manner as the inner, and, to prevent this outer layer of insulation being damaged, the entire cable thus formed is fitted into an outer tube of iron, which serves the purpose of a thorough mechanical protector. We thus obtain lengths of "cable," the conductors of which are perfectly insulated from one another and from the outer iron tube, while at the same time they are shielded from any exterior damage.

The lengths are jointed together as they are being laid in the streets, but are *sent out prepared for that purpose*, in the following manner. The ends of each length are respectively coned male and female.

A length of cable is placed in a hollow spindle lathe, and to form the male cone the outer iron shield is removed for a distance of 17 inches from one end; 14 inches of the outer insulation thus exposed is then taken off, leaving bare that length of the outer copper conductor; 6 inches of this conductor is now removed, and the insulating material between the two conductors is turned off, forming a core at the end of the cable.

At both the male and female ends the interior of the inner tube is slightly enlarged by drilling for a length of 6 inches from the end. The female end has its insulation coned out for a distance of 6 inches, while the iron shield is removed for a length of 11 inches, and the outer insulation for 8 inches, thus leaving the outer conductor exposed for that length.

For jointing together contiguous male and female ends, a tight-fitting copper rod, 12 inches long, is driven into inner tube at the female end. A tight-fitting sleeve of copper, 16 inches long, is driven for a distance of 8 inches on to the male end of the outer conductor, and is firmly locked to it by means of three or more circular corrugations or indentations.

The two cones are then inserted one within the other—are forced together and driven home by screw clamps, a total pressure of about 3 tons being employed—and when still under compression, the copper sleeve is firmly locked to the other outer conductor by means of circular corrugations, as described above.

The sleeve and the outer insulation are wrapped at the junction with insulating material until they become of the same external diameter as the iron tube, when an iron sleeve, 30 inches long, is passed over, and corrugated down at both ends on to the iron tube. In order to fill any possible air space in the outer insulation that may remain, hot compound is forced in through the boss of the sleeve, the hole being finally closed with a gas plug.

For an end view and further remarks upon the conductor, we refer our readers to Dr. Fleming's Institution paper, which we commence to publish this week.

THE ELECTRIFICATION OF "EFFLUVIA" FROM CHEMICAL OR VOLTAIC REACTIONS.

IT has been shown by Enright that where gases are given off during any voltaic or chemical reaction, the "effluvium" is, as a rule, charged with electricity. By the term "effluvium" is meant the gas or something carried up with it. Mr. J. Brown has recently been investigating the same phenomena. He finds, however, that when ordinary effervescence takes place, unaccompanied by any chemical change, no electrification can be observed in the "effluvia."

Not only does the occurrence of chemical change determine that of electrification, but the nature of it influences the nature of the electrification, the sign whether positive or negative being influenced according to the character of the chemical or voltaic action taking place, and this influence does not appear to be due to any "contact" effect.

The results of an elaborate series of experiments made by Mr. Brown appear to traverse the conclusion arrived at by Enright, namely, that nascent hydrogen and other gases become positively electrified by contact with acids and negatively electrified by contact with salts in solution.

To take a typical experiment, when the "effluvium" is that giving off when metallic zinc is dissolved in hydrochloric acid, and consists of hydrogen gas accompanied by "foggy" matter, it is not decided whether the charge of electricity is given originally to the gas or to the fog-particles, although the balance of evidence inclines towards the latter view. The "fog" in question appears to be formed at, or nearly at, the same time and place as the gas. And the nature of the charge of electricity which this "fog" possesses is therefore possibly influenced by the voltaic conditions which are present at this place.

These experiments also demonstrate that the gas or "effluvium" which arises from the decomposition of a liquid by the current proceeding from the pole of a separate battery immersed in this liquid, is also charged with electricity.

THE FRANKFORT ELECTRICAL EXHIBITION.

THE formal opening of this promising exhibition, as already announced in the last issue of the ELECTRICAL REVIEW, will take place on the 16th inst. at noon. It seems almost certain that this undertaking will be a great success from all points of view. Under that capable organiser, Herr Oscar von Miller, who earned well-deserved laurels at the Munich Electrical Exhibition of 1882, and who is assisted by influential honorary presidents and a committee of men of high standing, it seems almost a foregone conclusion that this international exhibition should have a prosperous career. The novel experiments with high tension currents for the electric transmission of power alone will attract numbers of engineers from all parts of the world. The city of Frankfort itself is most attractive, and more easily accessible by West European or American travellers than either Munich or Vienna. The Paris Exhibition of 1889 was void of any striking novelties in electrical engineering, and the world is looking forward to some new departures which are promised on this present occasion.

Some information on the general arrangement and scope of the Frankfort show may be gleaned from the first two numbers of the *Official Exhibition Gazette (Offizielle Ausstellungs Zeitung)*, dated April 15th and April 22nd respectively.

No. 1 contains the history of the origin of the present enterprise, which was initiated on the 30th November, 1889, by a meeting of members of the Electro-technical Society and other corporations of Frankfort. Dr. Adickes, Mayor of Frankfort, and his Excellency, Dr. Miquel, Minister of Finance, have been elected honorary presidents. Dr. Werner von Siemens, of Berlin, Dr. A von Waltenhofen, of Vienna, Mr. Thomas Alva Edison, of New York, Mr. Marcel Deprez, of Paris, and Dr. Silvanus P. Thompson, of London, were chosen as honorary members. The executive council consists of Mr. L. Sonnemann, Mr. O. von Miller, Mr. C. Stiebel, and Mr. A. Horkheimer. Then follows a large number of members of special committees, too numerous to mention in this place.

The ground plan of the exhibition comprises a considerable area, reaching from the central railway station to the Gallus-Anlage, a distance of nearly one-third of a mile, the principal boundary lines being the Kaiserstrasse and Gutleutstrasse, both diverging from the Gallus-Anlage. The exhibits are divided into the following 12 groups :—

I. Steam, air and gas motors.
II. Production of electric energy.
III. Distribution of electric energy.
IV. Accumulators and transformers.
V. Electric transmission of power.
VI. Electric lighting in all its branches.
VII. Telegraphy and telephony.
VIII. Electric signalling with its various applications.
IX. Electro-metallurgy and electrolysis.
X. Measuring instruments and scientific apparatus.
XI. Application of electricity for medical and surgical purposes.
XII. Electrical literature.

Out of 77,000 square metres area enclosed by the exhibition fences, 3,000 are occupied by the large machinery hall, which has a frontage of 27 metres, a length of 127·6 metres, and is 17 metres high in the roof; the centre cupola reaches to a height of 40 metres. Twenty steam boilers of a collective capacity of upwards of 3,000 horse-power supply steam for the sixty engines of different types, the largest of which is a triple expansion engine of 500 H.P. In addition to these are a number of gas engines, some actuated by ordinary illuminating gas, and others by Dowson gas generated on the spot. A considerable portion of this power is applied to driving dynamos of different descriptions, from the smallest laboratory apparatus up to machines taking 300, 500, and 600 H.P.

Various kinds of accumulators form part of the installation, and these require about 400 H.P. for continuous charging.

Electric motors, continuous and alternating current, will be used for almost every conceivable industrial purpose, as well as for driving all the machinery in the "model-mine."

Among the novelties in Group IX. will be found a new process of electro-plating plaster cast figures, giving them the appearance of solid bronze.

Altogether Mr. O. von Miller in his interesting "technical report on the exhibition" promises us some curious and highly instructive sights, which will be duly recorded in the pages of the ELECTRICAL REVIEW.

With regard to the financial success of the exhibition, the committee feels confident that the expenditure will be at least balanced by the income, and some stress is laid upon the sanction given by the Government that the tickets may carry an interest in, or be issued in connection with, a lottery scheme. The committee has furthermore been favoured with a number of money donations for specific purposes. The Imperial States fund contributes 10,000 marks towards the Lauffen-Frankfort transmission experiment; the Prussian Ministry of Commerce gave 15,000 marks for the construction of a mine worked by electric machinery: the German Post Office contributed 5,000 marks to assist in the exhibition of submarine telegraph apparatus of the Eastern Telegraph Company of London; the City of Frankfort subscribed 50,000 marks towards the construction of electric tramways connected with the exhibition; the Frankfort Chamber of Commerce gave 10,000 marks, and, together with other donations, the guarantee fund has already reached the sum of 700,000 marks.

LIFE OF SUBMARINE CABLES.

OUR attention has been called to the following paragraph which appeared in the *Mechanical World* of May 2nd :—

"A submarine telegraph cable has a life of 10 or 12 years. If a cable breaks in deep water after it is 10 years old, it cannot be lifted for repairs, as it will break of its own weight. On this account cable companies are prepared to put aside a large reserve fund, in order that they may be prepared to replace their cables every 10 years. The action of the sea eats the iron away so completely, as to turn the outside coating to dust or sediment, while the core is still intact. The breakage of an ocean cable is a very costly accident, owing to the difficulties to be encountered in repairing it. It often becomes necessary, in case of a break, to charter a ship at £100 per day for several days in succession, trying to fix upon the location where the cable has parted. One breakage in the Direct Cable Company's line a few years ago cost that syndicate over £26,000."

To those acquainted with the subject of submarine telegraphy, the incorrectness of the statements that a cable has a life of only from 10 to 12 years, and that after that age it cannot be repaired in deep water, is at once apparent. The general public, however, would be naturally ready to accept, without hesitation, the expression of an opinion coming from a presumably authoritative source, and we think our contemporary should be more careful, and take some little pains to ascertain the facts of the case, before making such random statements.

A hard and fast law as to the life of a cable cannot be laid down, for the duration of the sheathing wires is governed by more than one element. The quality of the galvanising, the presence or absence of such protection as compound, tapes, or hemp, and the physical and chemical nature of the bottom, are considerations which must be taken into account. To show that the *Mechanical World* is very far astray in its calculations, and that submarine cables may have a life of more than 10 years, and that they can be successfully repaired at even a considerably greater age, we may observe that there are now in existence and in working order, about 44,000 knots of cables, having a life of fifteen years and over; of this amount some 21,000 knots are twenty years (and over) of age. There are several instances of cables now working over 25 years old, but these are principally lines of unimportant lengths, and lying in shallow water. The cables we have cited are laid in all portions of the globe, and submerged in all sorts of depths; and although the companies owning them have spent, and are prepared to expend, considerable sums in repairs, we do not think that the complete renewal of each section every ten years has entered into their calculation.

Present experience would lead us to allot to submarine cables laid under favourable conditions an average life of from thirty to forty years, but, as before stated, no hard and fast figure can be given any more than it is possible to determine the number of years that each newly-born child will live, but there is abundant evidence to prove that our contemporary is distinctly wrong when he says "a submarine cable has a life of ten or twelve years."

THE SALZBURG ELECTRIC WORKS.

The Salzburg *Volksblatt* calls for a subscription of 50,000 florins in shares of the Salzburg Electric Works.

From this prospectus we extract the following interesting passages :—

"The bank herewith offers the last disposable sum of 50,000 florins for sale, as the other portion of the share capital has been already taken up.

"The undertaking comprises two very lucrative departments, each of which gives excellent receipts—the ascent in summer and the lighting department in winter.

"The number of glow lamps already installed is 3,028, and is continually increasing; the supply of light in 1890 amounted to 1,642,286 burning hours; the mechanical installation will this year amount to 400 H.P.

"The electric lift raised from August 9th to the end of December 66,712 persons and 1,035,650 kilos. of freight; its prosperity is universally known. The results have been hitherto :—

"For 1888—florins, 10,734·02, corresponding to 6⅓ on the share capital, 300,000 florins. The dividend has been 5 per per cent. for seven months.

"For 1889—24,643·25 florins, corresponding to 8¼ per cent. on the share capital of 300,000; dividend, 12 florins.

"For 1890—33,869·59 florins, corresponding to 9½ per cent. on the share capital of 300,000 florins; dividend, 14 florins.

"It may be assumed with certainty that these results will be higher in succeeding years, as the introduction of the electric light continues to make great progress, and the use of the lift is becoming more frequent.

"The shares will be issued at 207 florins, along with interest, from January 1st, 1891."

The accompanying data display the prosperity of the Salzburg electric works in a very favourable manner, which is, of course, satisfactory for electro-technicists, whose only wish is for the prosperity of electric works to become widely known, so as to give further inducements for electro-technical undertakings.

In this respect it is to be regretted that the prospectus did not include at least a brief extract from the balance sheet of the Salzburg works, so as to enable all concerned to satisfy themselves of the accuracy of the above figures.

This deficiency is the more striking, as a year ago the same shares were publicly offered at 230 or 220 florins, whilst now, after very satisfactory results, they are offered at the reduced figure of 207 florins, which is remarkable in case of a small residue of shares in a prosperous undertaking.

We learn that the publication of a balance sheet has been avoided, and it has merely been made known to the shareholders in short notices that the clear profit for 1891 has been 33,803 florins, and that a dividend of 7 per cent. was resolved on for the May coupons.

The data as to the details of the working of the electric lift are particularly striking. It was constructed on the supposition that a Mozart Jubilee theatre was to be erected on the Mönch'sberg.

This project has not been carried out, and the only attraction for visitors is the prospect tower erected by the Electrical Company on the Mönch'sberg, and a restaurant built under the same auspices. The lift can only have been used for two months.

The car of the lift holds only 12 persons, and if we consider that all the seats were not regularly taken up, we feel surprised that in a season beginning August 9th, 1890, 66,000 persons should have been conveyed to the top of the Mönck'sberg.

As to the 1,035,650 kilos. of freight, it represents simply the weight of the building materials which the company conveyed up for the construction of their own prospect tower, besides supplies for the restaurant.

It would be well if the Salzburg Electric Works would elucidate the question here raised.

NOTES.

The Electric Light at Southampton.—The works of the Southampton Electric Light Company were opened last week, and at a commemorative dinner the chairman (Alderman J. Miller), in proposing "Success to the Company," adverted to the difficulties which had had to be encountered, and said that now the work was completed he was glad to say that their customers were increasing from day to day, and he hoped in the course of a few months to see one of their principal streets lighted from top to bottom by means of electricity. Mr. R. E. Crompton, of the firm of Messrs. Crompton and Co., contractors for the works, said that the lighting would be carried out under the lower pressure system, which he believed to be the best and safest. The success of the undertaking, he added, would depend upon the management. On the opening day six large incandescent lamps, each of 500 candle-power, were placed on the ancient Bargate, which was brilliantly illuminated. At a given signal, Miss Miller, daughter of the chairman of the company, turned the switch at the switchboard. The company have given the requisite notices for the extension of their works.

Ship Lighting.—Messrs. J. D. F. Andrews and Co. have added another vessel to their list of electrically-lighted ships in the name of the *Genkai Marü*, the new Royal mail Japanese steamer, which has been built by Messrs. Napier, Shanks, and Bell. The principal feature of this installation is the system of wiring, which is Andrews's concentric system. The advantages of this system are that it completely embodies all the features of both the double and single wire systems, thus avoiding the danger of affecting the compasses, besides introducing the important feature of safety from fire, which is secured by the mode of construction of this cable. The wiring is exceedingly neat in appearance, and very easily laid over mouldings and panellings, a matter of considerable importance in ships, where it is desirable to have every conductor in view. The dynamo, which is for 150 16-C.P. lamps, is driven direct by an open vertical engine, fitted with a Pickering governor.

Electric Lighting at Lambton Castle.—The Earl of Durham has decided to thoroughly reorganise the electric lighting arrangements at Lambton Castle. It having been found that the existing machinery is of insufficient power to light the castle satisfactorily, an entirely new electrical generating plant comprising two "Cornish" boilers, each of 25 nominal H.P. and two "Parsons" steam turbines and dynamos of the new improved type, with automatic expansion, each capable of supplying 32 kilowatts, is to be erected by Mr. A. A. Campbell Swinton.

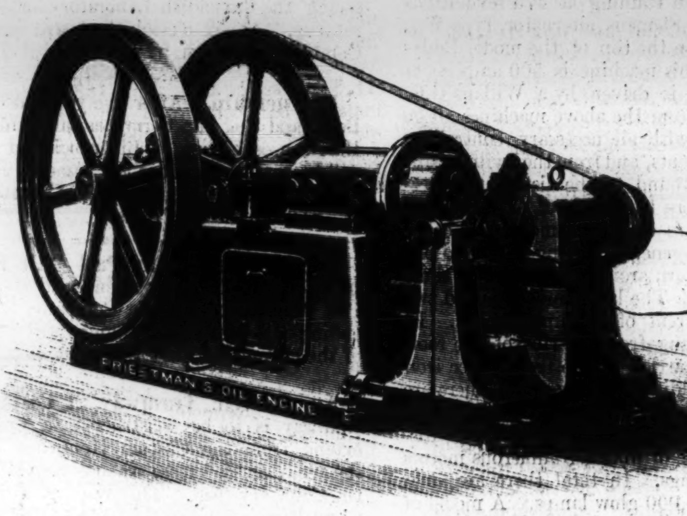
Utilisation of Water-Power in Italy.—An important work has recently been completed for supplying the power for an electric tramway between Pazzala and Lugano. The power is obtained from a waterfall, the water being conveyed in two iron pipes to the generating station, where two turbines of 300 H.P. each drive a 1,500-light dynamo, and a 60 H.P. generator.

Electric Lighting in Manchester.—Great enlargements of Paulden's well-known drapery stores, Stretford Road, Manchester, having just been made, it has been found necessary to greatly increase the electric lighting plant, so that when completed it will probably be the largest shop installation in the provinces. The original plant consists of a 200 H.P. compound engine driving two 400-light Edison-Hopkinson dynamos, four 10-arc Weston dynamos, and one 2-arc Gramme dynamo, about 300 50-C.P. incandescent lamps and 50 arc lamps being used. The new plant which is being put down comprises an additional engine of 130 H.P., three 10-arc Weston dynamos and one Edison-Hopkinson dynamo. 300 additional 50 C.P. incandescent lamps and 22 arc lamps are being put up.

The Institution of Electrical Engineers.—On Thursday, May 14th, a discussion on the following papers will take place :—" On some Effects of Alternating Current Flow in Conductors having Capacity and Self-induction," by Dr. J. A. Fleming, member. " Some points connected with Mains for Electric Lighting," by W. H. Preece, F.R.S., Past President.

The French West India Cable Company.—We notice in the French press of May 4th the announcement that the Société Française des Télégraphes Sousmarins has issued 14,200 bonds of 500 francs, bearing a 5 per cent. interest, and redeemable in 30 years at par. The issue is at 487·50 francs. The object is to obtain sufficient capital to complete the company's system which will have a total length of 3,641 nautical miles, and which is expected to be completed this year.

Novel Method of Electric Lighting.—Messrs. Priestman Brothers, Limited, of Hull, and 73A, Queen Victoria Street, London, E.C., have just supplied to Mr. G. Aspland, 6, York Street, Boston, one of their 3 H.P. oil engines and a Taunton dynamo, the latter made by Mr. F. M. Newton, of Taunton. The engine and dynamo are mounted upon a bogie fitted with road wheels complete. The dynamo is driven direct from fly-wheel of engine at a speed of 1,300 revolutions, and supplies 4 arc lamps with a current of 6 ampères at a pressure of 60 volts, the candle-power of each being about 1,000. All wire leads to lamps are attached to main cables by means of special brass clips which can be detached at a moment's notice. The above unique and well-finished installation is for lighting up a patent switchback. Messrs. Priestman Brothers, Limited, are now making oil engines from 1 H.P. to 25 H.P. A large number of engines have been supplied for electric lighting, orders having recently been executed, amongst others, for this purpose, for the Victorian and New South Wales governments.



Mechanical Engineers becoming Electrical.—Messrs. Easton and Anderson, Limited, have now made arrangements to add a new department to their engineering works at Erith, for the construction of electrical appliances, more especially dynamos and motors, and have with that object taken over the business of Mr. Napier Prentice, electrical engineer, of Stowmarket, Suffolk, who will have the superintendence of the department under the general manager of the works, Mr. F. W. Stoker. Being at the same time makers of engines and boilers both for direct and belt or rope driving, as well as of turbines and water wheels, the firm will be in a position to design and carry out themselves complete installations for the electric light, transmission of power, deposition of metals, and other applications of electrical energy.

South Staffordshire Tramway Company and Electric Traction.—The directors after carefully investigating the various methods of traction are prepared with the consent of the local authorities to recommend their shareholders to equip the tramway with the overhead system of electric traction.

The Bretel Vegetable Boiler Fluid.—The object of this composition is to prevent incrustation and corrosion in marine, land, or locomotive boilers. Amongst its most prominent features are claimed the following :—It prevents all incrustation and corrosion, and removes any scale already existing ; It causes a great saving in fuel, keeping the boilers clean and preventing rust ; it dispenses with the expenses incurred in chipping the boiler, and preserves the boiler so that it lasts twice the usual time ; it keeps the crowns of furnaces free from scale, and all fear of collapsing through overheat is prevented ; priming of water becomes impossible.

The O.S.A. Students' Meeting.—On Wednesday, May 13th, 1891, at 8 p.m., a paper will be read by Ernest B. Vignoles, member, on "Some Researches in Electro-magnetic Induction," describing an original method of obtaining force-induction-curves, for iron or other materials, for use in predicting dynamo characteristics, transformer actions, or the induction in magnetic circuits of any other kind, " together with tables and curves showing typical results for various kinds of iron and steel."

The Old Students' Conversazione.—The conversazione of the O.S.A. will be held on Friday next, commencing at 7·30 p.m. Some of the leading engineering, electrical and chemical firms have kindly consented to lend apparatus and products for exhibition during the evening. Prof. S. P. Thompson, D.Sc., will deliver a lecture entitled "Electricity in Motion." A concert will be given during the evening under the management and by the kindness of the Musical Committee of the Old Students' Association.

Ladies and the Telephone.—The Western Counties and South Wales Telephone Company have made a step in advance by issuing what they term a lady's complimentary call-room pass to the leading members of their subscribers' families, available for communication from any call-room in any town in the company's district.

Personal.—Mr. Percy E. Scrutton has ceased to have any connection with the Electrical Engineering Corporation, Limited, the secretary of which company he was until recently. Mr. J. C. Howell, Llanelly, S. Wales, has opened a London branch at the above address, of which Mr. Scrutton is the manager.

Mr. J. H. Garratt, Stud.Inst.E.E., has been appointed assistant electrical engineer by Mr. Ronald A. Scott, M.I.E.E., at the Acton Hill Electric Light Works.

The Naval Exhibition.—This most interesting exhibition was opened by the Prince of Wales last Saturday. It is not our intention to refer to the exhibits which have been fully described in the daily press. The whole of the grounds and covered spaces are fitted with a complete system of electric light. It is also used on board the model of the *Victory*, the glow lamps being placed inside the old-fashioned horn lanterns. Messrs. Siemens, who are responsible for the lighting, have supplied us with the following information :—The generating plant comprises seven locomotive type multitubular boilers, working at a pressure of 130 lbs. per square inch, made and supplied by Messrs. Davey, Paxman & Co., of Colchester; six Willans patent engines, made and supplied by Messrs. Willans and Robinson, of Thames Ditton; five continuous current Siemens dynamos, and one alternator, made and supplied by Messrs. Siemens Bros. & Co. The lighting has been arranged on the plan of a compact central station. There are three Siemens dynamos, type H.B. 24/36 shunt-wound, each capable of giving 1,500 ampères at a pressure of 120 volts, whilst absorbing 260 horse-power. Each of these dynamos is coupled directly to a Willans compound engine, type III., running at a speed of 350 revolutions per minute. There are two smaller sets of the type largely used in the Navy, viz., a Siemens H.B. 15/19 dynamo, coupled to a Willans vertical open type engine, and capable of giving an output of 200 ampères at a pressure of 120 volts, when running at 320 revolutions per minute, and a Siemens H.B. 16/19 dynamo, coupled to a Willans patent engine, type G.G., as used in the Navy, capable of giving an output of 400 ampères at a pressure of 120 volts, when running at 475 revolutions per minute. There is also a Siemens alternator, type W_{20}, with its exciter, for the light on the top of the model Eddystone tower. The output of this machine is 500 ampères at a pressure of 80 volts, and it is driven by a Willans G.G. engine, as above. The leads from the above machines all go to a switchboard provided with all necessary controlling devices and measuring instruments, and from the switchboard the feeding mains pass underground to the distributing network of conductors which covers the whole of the buildings and ground. These mains are of the Siemens lead-cased and iron-sheathed type. The general lighting is carried out by means of Siemens new pattern arc lamps, similar to those in use at the British Museum. The lamps are arranged two in series and work with a current of 9 ampères each. In the galleries the lamps are hung from the ribs of the roof, and in the grounds they are carried on 55 feet lattice iron masts in groups of six. In addition to the above, there are a large number of glow lamps in the dining rooms, offices, &c., and during the daytime current will be kept on the distributing mains for the purpose of working numerous motors in various parts of the buildings. In total there are close on 200 arc lamps, and about 5,000 glow lamps. A model of the Eddystone lighthouse, 170 feet in height, has a lantern 14 feet in diameter and 16 feet 6 inches high, and within it is a "double group-flashing dioptric" electric light "of the fourth order," composed of Chance reflecting lenses only, and containing an arc lamp stated to be of 5,000,000 candle-power —the most powerful in the world. This is carried out by the engineers to Trinity House. The whole of the telephonic communications connecting the various executive offices and the fire and police stations have been erected by the Universal Telephone Company.

Liverpool Corporation Laboratory.—At the meeting of the Lighting Committee of the Liverpool Corporation on Monday, the 4th inst., the city engineer presented a report by the electric inspector to the effect that the alterations and enlargements to the testroom and office had been completed and that the apparatus formerly in the hands of the Liverpoool Electric Supply Company, Limited, had been taken over at a total cost of £392 10s. 6d. and Mr. Yeaman reported that specifications of the instruments required to complete the equipment of the laboratory, had been sent to eight first-class firms. After some discussion the tender of Messrs. Nalder Brothers and Co., for certain instruments amounting to £264 17s. was accepted and it was decided that special instruments be obtained from White of Glasgow and Siemens of London at a cost of £88 and £43 8s. respectively. The appointment of a junior assistant in the laboratory was postponed for a fortnight.

The Elmore Copper Tube Process.—The *Engineering and Mining Journal* of New York had the following paragraph in its issue of April 18th :—"The more we investigate this matter the more convinced do we become of the need of warning American investors to whom the Elmore schemes may be presented that there are very serious doubts about the validity of the patents on any essential features of the process, and still greater doubts as to the value of the process itself. . . . . That the Elmore Copper Depositing Company is being used as a means of a gigantic stock-jobbing scheme there can be no possible doubt."

Physical Society of London.—Special meeting at Cambridge, Saturday, May 9th, 1891. Programme of proceedings: Leave Liverpool Street at 11 o'clock in train with special saloon carriages (first and third class). On arrival at Cambridge at 12.17 the members of the Physical Society will become the guests of the Cambridge members. Lunch in the Hall of Emmanuel College, by permission of the Master and Fellows, at one o'clock. Meeting at the Cavendish laboratory 2.30. The following communications will be read :—1. "Some Experiments on the Electric Discharge in Vacuum Tubes," by Prof. J. J. Thomson; 2. "Some Experiments on Ionic Velocities," by Mr. W. C. D. Whetham; 3. "On the Resistance of some Mercury Standards," by Mr. R. T. Glazebrook; 4. "On an Apparatus for Measuring the Compressibility of Liquids," by Mr. S. Skinner; 5. "Some Measurements with the Pneumatic Bridge," by Mr. W. N. Shaw." Members will afterwards have an opportunity of seeing the Cavendish Laboratory and other University laboratories. At six o'clock there will be tea in Trinity College Combination Room, by permission of the Master and Fellows.

Partnership.—After five years successful trading as E. L. Berry and Co., Mr. Berry has taken into partnership Mr. F. Harrison, engineer, of Liverpool, and in future the business will be carried on under the name of E. L. Berry, Harrison and Co., at new premises, Lyric Chambers, Whitcomb Street, W., near Piccadilly Circus.

The St. James's and Pall Mall Electric Light Company.—The electric current sold by the St. James's and Pall Mall Electric Light Company, Limited, for the quarter ending 31st March, 1891, amounted to £9,652. The whole of the current sold last year amounted to £12,282.

An Electric Tramway at Costa Rica.—An Electric tramway is to be constructed in Costa Rica, which will extend from the Custom House and station till it reaches the "Savannah," from whence it will return to the city by the Cemetery road. The tramway will fill a great want in Costa Rica.

The Barcelona-Marseilles Cable.—We extract the following from the *Gaceta Industrial y Ciencia Electrica*, of April 25th. "For the first time since its submersion seventeen years ago, the cable between Barcelona and Marseilles has been interrupted. The break occurred on the 3rd of April, at a distance of a little over ten miles from Barcelona. The telegraph steamer *Amber*, of the Eastern Telegraph Company, was immediately notified, and on the 9th that vessel left Gibraltar. On the 13th the broken end nearest Barcelona was grappled for, and was brought up and buoyed on the same day. The other end was then grappled for and was hooked on the evening of the same day, and on the 14th the cable was repaired and communication re-established between Barcelona and Marseilles."

Royal Society Soirée.—The Soirée of the Royal Society took place last Wednesday under the presidency of Sir William Thomson. The exhibits were of unusual interest including Roman remains dug up at Silchester, Mr. Wimshurst's alternating influence machine, Trotter's ranger for setting out railway curves, Prof. Oliver Lodge's apparatus to show an effect by light and induction similar to that produced by one vibrating string on another of like tone, and a series of photographs showing the disturbance of air when a gun is discharged. In our next issue we may be able to give a few more particulars of the various scientific instruments, &c., on view.

Origin of Electrical Terms.—The following delightful explanation of electrical units is from a paper misnamed *Wit and Wisdom*, for in this instance it is neither the one nor the other :—"Electricians use many odd terms in their technical conversation, which are but component parts of a dead language to most listeners. Thus we hear them speak of 'farad,' 'ohms,' 'joules,' 'amperes,' 'watts,' &c. The unity of capacity is one farad ; the unit of resistance, one ohm ; the unit of work, one joule ; the unit of activity, one watt ; the unit of quantity, one coulcomb ; the unit of current, one ampere ; the unit of magnetic field, one gauss ; the unit of pressure, one volt ; and the unit of force, one dyne. Odd as these names may sound to the ear, there is really nothing wonderful in connection with their origin, they all having been derived from the name of some man famous in his special field of electrical study. The Michael Faraday, George S. Ohm, and James P. Joule, famous English and German discoverers, gave their names to the first three units mentioned above ; James Watt and André M. Ampère, English and French inventors, to the two units following ; Charles A. Coulcomb and Carl F. Gauss, the former a Frenchman and the latter a German, give their name to the units of quantity and magnetic field. The volt is named for the Italian discoverer, Volto ; the dyne is derived from the root word of dynamo, itself meaning force."

Electrical Exhibition, Crystal Palace, 1891.—An electrical exhibition, on the same lines as the one which proved such a brilliant success in 1881, will be opened at the Crystal Palace in November, 1891, and be continued for some months. Applications for space must be made on printed forms, to be obtained from the Manager, Crystal Palace, which must be duly filled up and returned to him not later than 5th September, 1891. Mr. R. Applegarth, of 11, Queen Victoria-street, E.C., has been appointed assistant engineer to the exhibition, and all information can be obtained from him at that address. For this office we think that a better choice than that of Mr. Applegarth might have been made.

The Electrical Standards Committee.—A meeting was held on Monday at the Board of Trade. The following members were present :—Mr. Courtenay Boyle, Major Cardew, R.E. ; Mr. Graves ; Mr. Preece, F.R.S. ; Sir Wm. Thomson, F.R.S. ; Lord Rayleigh, F.R.S. ; Prof. Carey Foster, F.R.S. ; Prof. Glazebrook, F.R.S., and Dr. John Hopkinson, F.R.S. Prof. Silvanus Thompson attended and gave evidence on behalf of the London County Council.

NEW COMPANIES REGISTERED.

Whessoe Foundry Company, Limited. — Capital, £50,000 divided into 4,400 preference and 600 deferred shares of £10 each. Objects : To acquire the business of manufacturing engineers and contractors, carried on under the name of "The Owners of the Whessoe Foundry," at Darlington, and to carry on the business of mechanical, electrical and consulting engineers, tool makers, iron founders, metal workers, manufacturers, &c. Signatories (with one share each), H. J. Faiers, 11, Glencoe Terrace, Leytonstone ; G. C. Saddington, 49, High Street, Notting Hill., W. ; J. Stonier, 35, High Street, Islington, N. ; D. Read, 3, Heyford Terrace, Lambeth, S.W. ; A. White, 27, Clement's Lane, E.C. ; F. H. Jones, 2, Lonsdale Villas, Barnes, S.W. ; J. W. R. Watson, 144, Downham Road, Islington, N. The number of directors is not to be less than two nor more than five, the first to be nominated by the subscribers. Qualification, £500. Remuneration, £1,200 per annum divided between them. Registered on the 30th ult., by Andrew, Mellor and Smith, 27, Clements Lane, E.C.

Mills, Walker & Co., Limited.—Capital £15,000 in £10 shares. Objects : To adopt an agreement with J. H. Walker for the purchase of the business carried on by him under the name of "Mills, Walker & Co.," as a manufacturer of glass, lamps, chandeliers and fittings for electric lighting, at Wordsley Glass Works, Staffordshire, and at 19, Charterhouse Street, London, E.C., and to carry on the business in all its branches. Signatories (with one share each) : Mrs. Walker, Ashfield, Wordsley, Stafford ; G. Harward, 118, High Street, Stourbridge ; H. Mills, 118, High Street, Stourbridge ; R. J. Heckford, 11, Hagley Street, Stourbridge ; G. H. Goodyear, 118, High Street, Stourbridge ; D. Hadley, 118, High Street, Stourbridge ; G. Daynes, 118, High Street, Stourbridge. The number of directors is not to be less than three nor more than seven, the first being P. Pargeter, H. Mills, J. Bolton and B. Robinson. Qualification, 10 shares. Remuneration is to be fixed by the shareholders in general meeting. Registered on the 1st inst. by Waterlow Brothers and Layton, Limited, 24, Birchin Lane, E.C. Office, Glass Works, Wordsley, Stafford.

Armstrong's Glass Company, Limited. — Capital, £10,000 in £10 shares, of which 500 are "A," and 500 are "B" shares. Objects : to enter into an agreement with John Armstrong, and to carry on at Albion, in Stafford, and elsewhere, the business of glass makers and stainers, glass workers, manufacturers of articles made of glass, electric engineers and fitters, and sanitary engineers and fitters. Signatories (with one share each) : J. Grubb, Alvechurch, Worcester ; W. Littleboy, 43, Beaufort Road, Birmingham ; W. H. Sturge, 17, Frederick Road, Birmingham ; G. S. Albright, The Elms, Edgbaston ; J. Armstrong, Leamington Park, Acton, W ; W. King, 19, Highfield Road, Edgbaston ; H. Glaisyer, Birmingham. The number of directors is not to be less than three nor more than five, the first being C. Butler, J. Grubb, W. King, and J. Armstrong. Qualification, 10 shares. Registered on the 28th ult. by Waterlow Brothers and Layton, Limited, 24, Birchin Lane, E.C.

Merrall and Son, Limited.—Capital, £402,000 in £100 shares. Objects : To purchase the business of worsted spinners, heretofore carried on by Merrall and Son, at Lees and Ebor, near Haworth and Oxenhope, York ; to adopt the agreement mentioned in clause 3 of the articles for the purpose ; to carry on the business of worsted spinners, wool and yarn merchants, bleachers and dyers ; to carry on the business of a water supply company and to construct and maintain all kinds of apparatus for the purpose ; to carry on the business of a gas supply company and an electric power company ; and to construct, manufacture, lay down, maintain and deal in buildings, pipes, cables, wires, lines, accumulators, lamps, fittings, machinery and apparatus. Signatories (with one share each), G. Merrall, Haworth ; Mrs. Merrall, Law House, Haworth ; E. R. Merrall, Haworth ; Mrs. Merrall, Laylands, Haworth ; A. Merrall, Haworth ; Mrs. Merrall, Ebor House, Haworth ; M. H. Merrall, Haworth. The number of directors is not to be less than two nor more than five, the first being G. Merrall, E. R. Merrall and A. Merrall who are called the founders and also permanent directors. Qualification, one share. Remuneration to be fixed at the general meeting. Registered on the 5th inst, by Molson Brothers, 8, Brownlow Street, Holborn, W.C. Offices, Lees, Haworth, York.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Electrical Engineering Corporation, Limited.—At an extraordinary general meeting of this company, held on the 23rd ult., the following resolution was passed, "That it has been proved to the satisfaction of this meeting that the company cannot, by reason of its liabilities, continue its business, and that it is advisable to wind up the same and accordingly that the company be wound up voluntarily," and at the same meeting Mr. F. W. Pixley, of 24, Moorgate Street, London, E.C., chartered accountant, was appointed its liquidator. Office, 24, Princes Mansions, Westminster, S.W.

Halifax Mutual Electric Light and Power Company, Limited.—The first annual return of this company, made up to the 31st December, 1890, was filed on the 21st ult. The nominal capital is £20,000 in £5 shares. 1,026 shares have been taken up, upon 921 of which £1 10s. per share has been called and upon the remainder the full amount has been considered as paid. The calls paid amount to £1,127, considered as paid to £525 and unpaid to £254 10s.

The second annual return, made up to the 4th, ult., was also filed on the 21st ult. 1,126 shares have been taken up, upon 1,121 of which £3 10s. per share has been called. The calls paid amount to £3,888; considered as paid to £525 and unpaid to £35. Offices, Square Road, Halifax.

Newcastle-upon-Tyne Electric Supply, Company, Limited.—The annual return of this company, made up to the 14th ult., was filed on the 22nd ult. The nominal capital is £50,000 in £5 shares. 4,084 shares have been taken up, upon 3,000 of which £4 per share has been called, upon 1,066 £3 per share has been called, and upon the remainder the full amount has been considered as paid. The calls paid amount to £16,144, considered as paid to £90, and unpaid to £40. Office, Pandon Dene, Newcastle-upon-Tyne.

Simplex Electrical Syndicate, Limited.—The annual return of this company, made up to December 31st, 1890, was filed on the 20th ult. The nominal capital is £6,000 in £50 shares. 120 shares have been taken up, upon 60 of which the full amount has been called and paid, and upon the remainder the full amount has been considered as paid. Office, 109, Farringdon Road, London, E.C.

Regenerative Electric Supply Company, Limited.—The following notice was filed on the 23rd ult.: A meeting of this company was held on the 16th ult. for the purpose of having an account laid before them showing the manner in which the winding up of the Company had been conducted and the property of the Company disposed of, and that the same was done accordingly. Offices: 7, Westminster Chambers, Victoria Street, Westminster, S.W.

Electrical Supplies and Fittings Company, Limited.—The annual return of this company, made up to the 17th March, 1891, was filed on the 24th ult. The nominal capital is £20,000, divided into 3,800 ordinary and 200 founder's shares of £5 each. 126 ordinary and 76 founders' shares have been taken up, and upon all of the founders' the full amount has been called, and upon the remainder £1 10s. per share has been called. The calls paid amount to £560, and unpaid, to £10 10s. Office: 15, St. Helen's Place, E.C.

CITY NOTES.

Brazilian Submarine Telegraph Company.

Sir James Anderson presided at the annual meeting held on Wednesday last. The report published in our last issue was taken as read.

The Chairman then said he would ask their leave to refer, first, to paragraphs 4 and 6 of the report, in which they would find that they had lost from among them their chairman and Sir Thomas Fairburn. Their obligations had become so onerous for them, on account of prolonged ill-health. Shareholders would join with him in hoping that the repose which they sought would bring health and comfort. They had filled the vacancies by two exceptional gentlemen, Lord Sackville Cecil and Mr. John Denison Pender, who had acquired the knowledge of the ramifications and negotiations in cable business which were far more numerous than shareholders were aware of. It was a source of satisfaction to him that they could find young men who could take the place of those who were rapidly going behind the scenes. He proposed to give them one or two points which would show the necessity for a strong board. He did not want to alarm them, for he did not take a despairing view of the situation; but he thought it would be wrong on his part not to say that they were on the eve of an anxious time, if not a crisis. In spite of this, however, they would be able to give as good as they got, and those in opposition would find that they were opposing two companies well up to their work. The chairman then referred particularly to the line which would be likely to affect them. However, they had duplicated their lines all through the system, which consequently made them strong. It had also been the policy of the board, since the inception of the company 18 years ago, to lay by a large reserve, and it had reached such proportions that they were able to pay for the whole of the duplication without any addition to capital. Besides, they had in securities £400,000 as a substantial addition to the growing reserve. Shareholders, from this, would naturally expect larger dividends and larger bonuses; the bonuses they would consider at the next meeting, but as to dividends, he would urge them to be satisfied with what he called the present good dividend, and to encourage the directors to amass as much reserve as possible while times were good; because, when the opposition lines were laid, they would have no other alternative policy than reducing the tariffs. Of course, having, as he said, duplicated the lines, they would be in a position to meet all comers. Possibly they might have reduced the tariffs sooner but for the fact that new lines had been threatening for some time. Taking the worst view of the case, he did not despair of a fair dividend and an addition to the reserve. They occupied a good position, and they must, he thought, see that with a large reserve growing, and the power of extending their system more than perhaps their opponents were aware of, that the company was practically invulnerable. They had no necessity to be afraid of their opponents. They could not, of course, hope to keep a monopoly for ever, but with their duplications, and credit at the bankers, they had little to fear.

The Chairman, after referring to financial items, proposed the adoption of the report, which was carried.

The Great Northern Telegraph Company of Copenhagen.

The following abridged report of the general meeting held at Copenhagen on the 25th of April, 1891, has been supplied to us by the company.

The Chairman (C. F. Tietgen, Esq.), in rendering an account of the working of the company during the year 1890, referred to the company's cables, which, he said, had been subject to about the same number of interruptions as during the previous year, viz., 27 in all; 14 on the European, and 13 on the Far East cables. The company's cable steamers had, in consequence, been fully employed. Having regard to the numerous interruptions, the company had every reason to congratulate itself upon the decision arrived at in 1890, to lay a new direct cable between England and Sweden, and also a second cable between France and Denmark. Although there were other business matters which had required urgent attention, nothing had been left undone to accelerate the realisation of these projects. As under the existing agreements with the British and Swedish Governments only a few minor points had to be settled, the laying of the new English-Swedish cable had already been accomplished in November last. The cable, which was 509 nautical miles long, and connected Newbiggin-on-the-Sea with Gothenburg in Sweden, had been manufactured and laid by the Telegraph Construction and Maintenance Company, Limited, of London, who had carried out the work very successfully, and to the entire satisfaction of the company. The new line was opened for traffic on the 23rd November last, and had been working very satisfactorily up to the present. The negotiations with the Danish, and especially with the French Governments, relating to the laying of the new cable between Calais and Fanoe in Denmark, had been of a somewhat more protracted nature, owing to the necessity of applying for a prolongation, and to some extent modification, of the existing conventions. Although the delay was to be regretted, still it had this advantage, that the cost of the new cables could be spread over two financial years, and the investments already made on account of the reserve fund left intact. Some time ago, an agreement had been concluded with the Japanese Government, by which the length of the company's cables in the Far East would be slightly reduced. By this agreement, two short lengths of cable (57 nautical miles in all), laid by the company in 1884 between the Japanese Islands of Kiusiu, Iki, and Tsushima, had been transferred to the Japanese Government, who were anxious to add them to their internal telegraph system. Although the company would have preferred to retain the ownership of these cables, which formed an integral portion of the line between Japan and Korea, they had ultimately yielded to the wishes of the Japanese Government, who had always given the company very marked proofs of sympathy and goodwill. The building of the company's new offices in Copenhagen had made so much progress that they were expected to be ready for occupation before the end of the year. The traffic receipts had amounted to about £280,000, which was a higher figure than had been reached in any previous year. It was to be hoped that the saving thus effected in the yearly expenses of the company would amply counterbalance the before-mentioned tariff reductions during the period which would elapse before the natural development of the traffic could gradually effect the same object. It might also be considered an advantage that the new tariffs would not come into force until the 1st July next, the loss incurred during the first twelve months being thus spread over two financial years. Owing to this favourable position, the board of directors have been enabled to recommend that the extra dividend, which, after the Berlin Conference, had been reduced to 5s., be increased by 2s. 2d., making the total dividend for the year 17s. 2d. per £10 share, or about 8·60 per cent. They also recommended to add a somewhat larger amount than usual to the reserve fund, in order to meet the heavy expenses in connection with the laying of the new cables. In conclusion, the Chairman referred to the deaths of Mr. L. P. Holmblad and Mr. H. G. Erichsen, who had taken a most active part in the promotion of the company. The report was then adopted, and the retiring directors and auditors re-elected.

The West India and Panama Telegraph Company, Limited.

The report of the directors and the accounts for the half-year ended December 31st, 1890, states that the amount to credit of revenue is £43,978 19s. 8d. (against £42,768 0s. 1d. for the corresponding half-year of 1889), and the expenses have been £21,898 3s. 11d. (against £27,071 7s. for the same period in 1889), leaving a balance of £22,080 15s. 9d., which, with £322 6s. 8d., brought from last account, make a total of £22,403 2s. 5d., with which it is proposed to deal as follows:—

First Preference Shares—			
Dividend, 6 months to 31st December, 6s. per share	10,368	18	0
Second Preference Shares—			
Balance of arrears of dividend to 30th June, 1890, 28s. 6d. per share	6,653	6	6
Dividend, 6 months to 31st December, 6s. per share	1,400	14	0
Ordinary Shares—			
9d. per share (free of income tax)	3,312	0	9
Balance to current half-year's account	668	3	2
	£22,403	2	5

The traffic receipts for the six months show an increase of £1,608 10s. 2d. as compared with the corresponding period.

The expenses of repairs to cables amount to £9,155, being £4,966 less than those for the corresponding six months.

Referring to the directors' report of the 23rd April, 1890, the result of the negotiations with the Colony of Martinique has been the acceptance by the company of £500 in settlement of its claims.

The shareholders have already been informed that negotiations were pending for laying a new cable between Demerara and Trinidad. These negotiations have resulted in an ordinance of the present year enacted by the Governor of British Guiana and the Court of Policy, by which an annual subsidy of £4,500 is payable to the company during a period of ten years, subject to the laying of a new cable between that colony and Trinidad, and the maintenance of telegraphic communication in terms of the said ordinance. The directors recommend that this cable should be laid in the course of this year, for which purpose, as also for the Barbados-St. Vincent cable laid in July last, a sum not exceeding £50,000 will be required, and as the existing £50,000 5 per cent. debentures fall due on the 31st December next, the shareholders will be asked to empower the board to borrow a sum of £100,000 and to issue debentures or other securities at such times, with such security, and upon such terms as the directors may think proper. The borrowing powers of the board will thus be limited to the £100,000, which will be applied for the new cables and the payment at maturity of the £50,000 existing debentures. Considering the loss sustained by the company in the past from the suspension of subsidies, loss of traffic, the heavy expenses of forwarding messages during interruptions in the above sections, and the serious cost involved in urgent repairs, the directors are of opinion that the telegraphing public, as well as all classes of the company's shareholders, will be benefited by the proposed outlay.

It will be remembered that the original subsidy of £800 per annum granted by the colony of St. Vincent was, in consequence of the severe commercial depression, reduced in 1887 to £400 per annum. An improvement in the colony's finances having taken place, the subsidy has now been increased to £600 per annum—a considerate recognition of the company's need for support which the directors have much satisfaction in acknowledging.

The ss. *Duchess of Marlborough* has been brought home for repairs. She arrived on the 4th inst., and on the completion of her repairs she will take out 70 knots of cable, which is now being manufactured by Siemens Brothers & Co., Limited.

In accordance with the articles of association, Charles William Earle, Esq., and William Ford, Esq., retire at this meeting, and offer themselves for re-election.

John George Griffiths, Esq., the auditor, also retires, and offers himself for re-election.

REVENUE ACCOUNT from July 1st, 1890, to December 31st, 1890.

DR.	£	s.	d.
To General expenses in London	1,228	0	3
„ Working expenses at 21 stations	7,669	17	10
„ Cost of repair to cables, &c., and expenses and repairs of maintenance ships	9,155	4	7
„ Reserve for depreciation of ships	501	12	1
„ Depreciation of cable tanks and hulk, cable covering machine and stores, &c.	82	9	0
„ Maintenance of land lines	846	4	2
„ Directors' remuneration	1,050	0	0
„ Auditor's fee	21	0	0
„ Interest on debentures	1,250	0	0
„ Income tax	93	16	0
	£21,898	3	11
„ Balance down	22,080	15	9
	£43,978	19	8
„ Dividends—			
First preference shares—			
Dividend, 6 months, to 31st December, 1890, at 6 per cent. per annum	10,368	18	0
Second preference shares—			
Balance of arrears of dividend to 30th June 1890, 28s. 6d. per share	6,653	6	6
Dividend, 6 months, to 31st December, 1890, at 6 per cent. per annum	1,400	14	0
Ordinary shares—			
9d. per share (free of income tax)	3,312	0	9
	£21,734	19	3
„ Balance	668	3	2
	£22,403	2	5

CR.	£	s.	d.
By Messages, subsidies, &c., deducting cost of news supplied to colonies, &c....	43,910	7	2
„ Transfer fees	57	0	0
„ Interest	11	12	6
	£43,978	19	8
Balance from last half-year	322	6	8
Balance brought down	22,080	15	9
	£22,403	2	5

BALANCE SHEET to 31st December, 1890.

Dr.	£	s.	d.
To Capital, viz.:—			
88,321 ordinary shares of £10 each, fully paid, part of 165,000 shares authorised ...	883,210	0	0
34,563 6 per cent. first preference shares of £10 each, fully paid...	345,630	0	0
4,669 6 per cent. second preference shares of £10 each, fully paid, part of 10,000 shares authorised	46,690	0	0
	£1,275,530	0	0
(Of the above, 52 ordinary shares in the old company had not been exchanged for shares in the new company up to the 31st December.)			
„ Debentures, bearing 5 per cent. interest... ...	50,000	0	0
„ Sundry credit balances	9,181	0	5
„ General reserve account, plus interest on investments (£2,872 1s. 8d.)...	146,613	14	2
„ Reserve for depreciation of ships, plus added this half-year (£501 12s. 1d.), less cost of docking and repairing *Grappler*, in London (£963 11s. 1d.)	9,613	8	1
„ Unclaimed dividends	283	13	3
„ Dividends—			
First preference shareholders—			
Six months, to 31st December, 1890, at 6 per cent. per annum	10,368	18	0
Second preference shareholders—			
Balance of arrears to 30th June, 1890, 28s. 6d. per share	6,653	6	6
Dividend, six months to 31st December, at 6 per cent per annum	1,400	14	0
Ordinary shareholders—			
9d. per share (free of income tax) ...	3,312	0	9
„ Revenue account—balance	668	3	2
	£1,513,624	18	4

CR.	£	s.	d.
By Capital expenditure, viz.:—			
Cables, stations, land lines, instruments, concessions, and other assets...	1,278,309	3	5
„ Cable in stock	21,884	7	8
„ SS. *Grappler*, cable machinery and stores ...	19,155	19	7
„ SS. *Duchess of Marlborough*, cable machinery and stores	12,875	17	0
„ Ships' stores in stock	620	10	2
„ Insurances on ships paid in advance	486	11	2
„ Cable tanks, cable covering machine and stores, &c.	1,434	9	3
„ Cable hulk	132	0	8
„ Sundry debit balances	8,043	18	8
„ Bills receivable	12,164	14	7
„ Remittances in transit	3,403	0	0
„ Cash balances at bankers and in the hands of liquidators and agents and on deposit ...	15,693	5	3
„ investments in respect of reserve funds costing...	139,421	0	11
	£1,513,624	18	4

Submarine Cables Trust.

THE report of the trustees to the twentieth ordinary annual meeting of the certificate holders, held at the offices of the Trust, No. 50, Old Broad Street, London, on the 5th day of May, 1891, states that the accounts for the financial year to 15th April, 1891, are submitted herewith.

The revenue for this period, including the balance of £431 8s. 11d. brought from the previous accounts, amounted to £24,098 3s. 3d.

The coupons due on 15th April, 1890, were paid on 15th October, 1890, and the coupons due on 15th October, 1890, were paid on 15th April, 1891.

The expenses of the Trust amounted to £1,175 7s. 6d., and the payments on account of the coupons to £20,286, together £21,461 7s. 6d., leaving a balance of £2,636 15s. 9d. to be carried forward. This balance, which is equivalent to 15s. 7d. per cent. on the value of the outstanding certificates, the trustees propose to distribute to the certificate holders on the 15th proximo, together with a small amount to be taken from the current year's revenue, so as to admit of the payment of £1 on account of the coupon due on 15th inst.

A table showing the original and present investments of the Trust is appended to this report.

The meeting will have to elect two auditors for the current year; Mr. John G. Griffiths and Mr. John Gane offer themselves for re-election.

REVENUE ACCOUNT to April 15th, 1890.

Dr.	£	s.	d.
To Expenses from April 15th, 1890, to this date, as provided by the Trust Deed, less unexpended (£824 12s. 6d.)	1,175	7	6
" Balance	22,922	15	9
	£24,098	3	3
To Interest Coupons			
" Coupon due 15th April, 1890, paid October 15th, 1890 (£10,143); coupon due 15th October, 1890, paid April 15th, 1891 (£10,143)...	20,286	0	0
" Balance carried forward	2,636	15	9
	£22,922	15	9

Cr.	£	s.	d.
By Balance from previous year...	431	8	11
" Dividend on stocks and shares forming trust investments	23,401	17	9
" Profit on temporary investment of revenue funds	264	16	7
	£24,098	3	3
" Balance	£22,922	15	9

BALANCE SHEET, 15th April, 1891.

Dr.	£	s.	d.
To 4,200 certificates of £100 each (£420,000), less 819 certificates cancelled per last account (£81,900)	338,100	0	0
" Sundry creditors	54	3	4
" Certificate holders—			
Interest coupons not presented	273	2	6
£3 per cent. payable April 15th, 1891	10,143	0	0
" Redemption fund—			
Profit on sale of securities and allotment per last account	12,449	13	2
Surplus revenue applied, to date	38,552	13	6
" Revenue account	2,636	15	9
	£402,209	8	3

Cr.	£	s.	d.
By investments—			
Anglo-American Telegraph Company, Limited...	162,938	8	2
Eastern Telegraph Company, Limited	82,723	19	0
Eastern Extension Telegraph Company, Limited	93,738	0	9
West India and Panama Telegraph Company, Limited	879	2	6
Great Northern Telegraph Company	146	7	6
By Original rebate to certificate holders on the nominal amounts of the certificates, as per prospectus...	42,000	0	0
" Premium paid on purchase of cancelled certificates (less discount on 50 purchased below par) ...	6,676	8	9
" Sundry debtors			
" Cash—			
Glyn and Co., general account	12,814	12	5
Glyn and Co., dividend account	273	2	6
" Petty cash	19	6	8
	£402,209	8	3

The twentieth ordinary annual meeting of the shareholders of the Trust was held on Tuesday at the offices, Winchester House, Old Broad Street, Sir John Pender, K.C.M.G., in the chair.

The CHAIRMAN, in moving the adoption of the report, said the revenue for the year was £23,666, as against £23,094, showing an increase of £572. Of this increase £264 arose from a small profit made by the trustees on a temporary investment, and the remainder from the improvement in the dividend received on their investments in the Anglo-American scheme. Their expenses for the year amounted to £1,175, as compared with £1,274, showing a saving of £99. Their expenses for 1888 and 1889 were over £1,380, so that they were working at the rate of £205 per annum less than formerly, the economy shown being mainly due to their not having filled up the vacancy on the board caused by the death of Sir Daniel Gooch. The small increase in revenue, coupled with the decrease in the expenses, might be considered as satisfactory, as the accounts showed that they were now earning 6¾ per cent. on the amount of their outstanding certificates. Their coupons were six months in arrear, and while they were in that position the certificate holders would receive, in addition to the usual 6 per cent., as much as possible in reduction of the overdue coupon. They proposed paying £1 on the 15th inst., and the balance of £2 as soon as they had sufficient money in hand for the purpose. In conclusion, he remarked that as all the submarine companies in which they had invested were doing well, and their dividends were increasing, the Trust should correspondingly prosper.

The Marquis of TWEEDDALE seconded the adoption of the report, which was carried, and, the retiring auditors having been re-elected, the proceedings closed with a vote of thanks the chairman.

The Western and Brazilian Telegraph Company, Limited.

THE report of the directors to be presented at the twenty-first ordinary general meeting of the company, to be held to-day, states that the total earnings amount to 108,817 10s. 5d. as against £86,403 0s. 7d., showing an increase of £22,414 9s. 10d. compared with the half-year to 31st December, 1889. The working expenses amount to £37,200 2s. 4d., as against £40,391 11s. 9d., a decrease of 3,191 9s. 5d. Including the amount brought forward from 30th June, 1890 (£5,751 7s.) and the dividend received upon the shares held in the "Platino" Company, the balance to the credit of the revenue account is £86,602 5s. 1d., from which has been deducted £13,164 for debenture interest, and £5,936 for the debenture redemption fund, leaving £67,502 5s. 1d., of which £20,000 has been placed to the reserve fund. The directors now recommend the payment of a dividend of 9s. per share, free of income tax, on the ordinary shares for the half-year, making with the dividend paid in November last, £5 per cent. for the year, leaving a balance of £6,070 6s. 1d. to be carried forward. In the case of shares which have been divided into "preferred" and "deferred," 1s. 6d. per share of the dividend now recommended will be payable to the "preferred" shareholders, and 7s. 6d. per share to the "deferred" shareholders. The second annual drawing of the "A" and "B" debentures took place at the Company's offices on the 16th January last in the presence of Mr. W. W. Venn, Jun., notary, when debentures amounting to £11,900 were drawn, and have since been paid off at par. A contract for the duplication of the Company's lines between Pernambuco and Santos has been entered into with the India Rubber, Gutta Percha and Telegraph Works Company, Limited. The ship carrying this cable will leave in a few days.

Since the last report 10 "Platino" shares have been exchanged for 6 shares of this Company. The dividend warrants will be posted on the 15th May, 1891. The retiring directors are Mr. W. S. Andrews and Lord Richard H. Browne, who offer themselves for re-election. The auditors, Mr. John Weise and Mr. John G. Griffiths, retire, and are eligible for re-election.

Kensington and Knightsbridge Electric Light Company.

THE annual meeting was held on Monday last at 1, Great George Street, Westminster, Mr. G. R. Ryder presiding.

The CHAIRMAN, in proposing the adoption of the report, said that during the year they had added four miles of mains to their streets, leaving practically only three to be done, the area over which they had power being about 13 miles, and already 10 were completed. The number of houses and shops connected with their system, to which they were serving light, had increased during the year from 147 to 291, and the number of lamps—taking them at 8 candle-power—from 11,794 to 25,535. That rate of increase had been fully maintained in the few months that had expired of the present year, and the number of their customers on April 30th last had increased to 342, and the lamps to 30,455, which, he thought, was a very satisfactory increase. As to the future prospects of the company he thought they were excellent. The staff had for some time been making a very careful calculation as to the average gross income received from each lamp per annum, and they found that 10s. was a fair amount to put down for that item. If they had 40,000 lamps, that, at 10s. a lamp, would produce a gross income of £20,000 a year, and they calculated that their present plant would carry 40,000 lamps. Out of the net £20,000 they calculated that they would obtain a net profit of from 35 to 40 per cent. which would give from £7,000 to £8,000 a year to be divided among the shareholders. After paying all the preference shareholders that amount would leave sufficient to pay a very good dividend on the ordinary stock.

Mr. HOPKINSON seconded the motion, and the report was unanimously adopted.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts of the Brazilian Submarine Telegraph Company, Limited, for the week ended April 24th, 1891, amounted to £5,998; and for the week ended May 1st, £5,444.

The City and South London Railway Company. Traffic receipts for the past week, were £733.

The Cuba Submarine Telegraph Company, Limited. The estimated traffic receipts of the Cuba Submarine Telegraph Company, Limited, for the month of April, were £3,700, as compared with £3,624 in the corresponding month of last year.

Direct Spanish Telegraph Company, Limited. The estimated traffic receipts for the month of April, 1891, are £1,825, as against £2,080 in the corresponding period of last year.

The Great Northern Telegraph Company. Receipts in April, 1891, £23,600 1st January to 30th April, 1891, £88,000; corresponding months 1890, £81,800; corresponding months 1889, £84,000.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending May 1st, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Company, were £4,363.

ALUMINIUM.*

BY CH. ED. GUILLAUME.

SINCE *La Nature* described the first electro-chemical methods of manufacturing aluminium bronzes and brasses, this branch of industry has advanced with giant strides. M. Héroult, by slightly modifying his methods, has succeeded, at the same time as Dr. Kiliani, in preparing pure aluminium by the incandescent electrolysis of melted aluminium; important works established at Froges (Isère) by a French company with a provisional capital of 650,000 francs, and a colossal installation at Neuhausen (Switzerland), set up by a company with a capital of 10,000,000 francs, pour into the European market in aluminium and aluminium brasses and bronzes, a quantity of metal from two to three hundred times as great as that produced a few years ago. In fact, the works at Salindres, by far the most important up to now, produced in 1887 as nearly as possible two tons of aluminium. At the present day, the Neuhausen works supply a ton a day, and the French Electro-Metallurgic Company about 600 kilogrammes; the quantity produced by the latter company will soon be greatly increased.

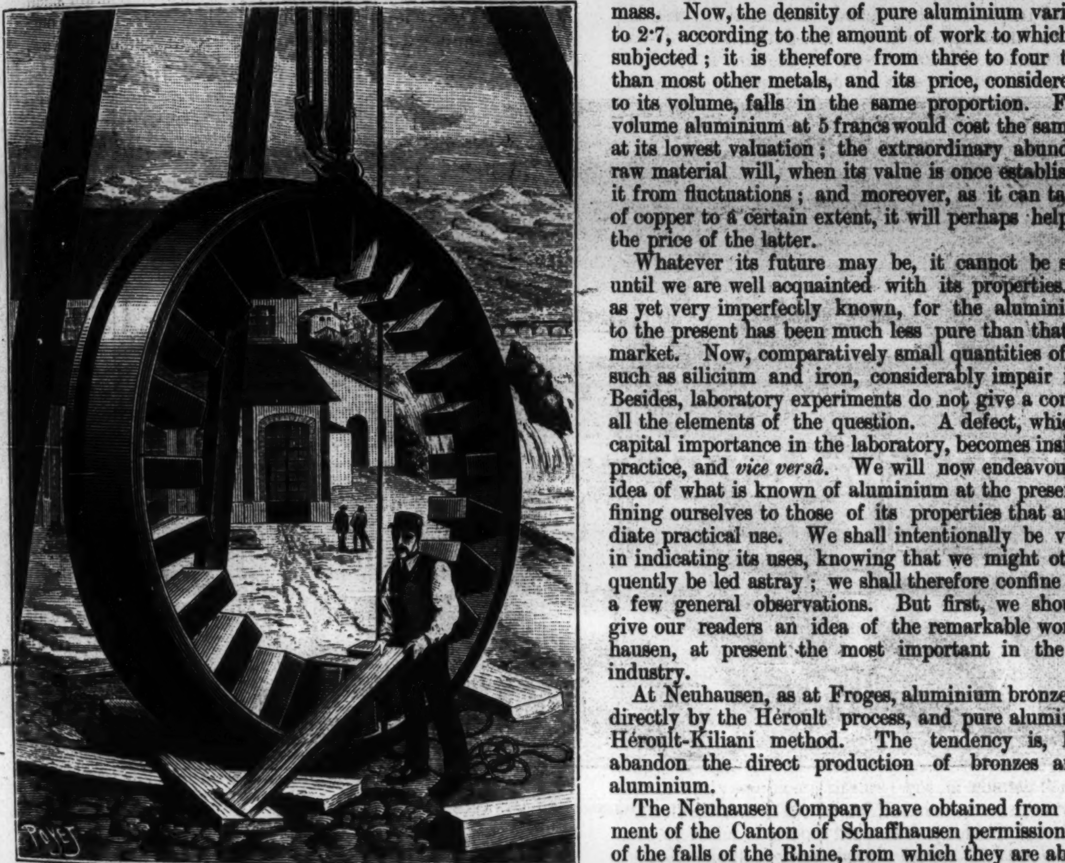


FIG. 1.—BODY OF THE INDUCTOR OF THE GREAT DYNAMO AT NEUHAUSEN.

This sudden advance in the aluminium industry was foreseen; Saint Claire Deville foretold it clearly and measured its importance. To produce aluminium cheaply has been for many years one of the problems to the solution of which the greatest amount of effort has been devoted. It is to the immense progress made in the technique of electricity that we must attribute the fact that the solution of this important problem has been found in so many countries simultaneously; this solution, although not as yet quite complete, being nevertheless very advanced.

In fact, the price alone of aluminium, which was until recently 120 francs per kilogramme, prevented its taking the place in industry that its valuable properties claimed for it. Now, pure aluminium costs from 18 to 20 francs, and when we shall have passed through the irksome period of trials and installations, and when also we are helped by the lowering of the price and the increase of the consumption, the general expenses of manufacture will be only a few hundred francs per ton of aluminium, and we shall see the price of this metal reduced by one-half, or even two-thirds. As long as we have not found entirely new methods of producing the metal, we shall be limited by the cost of the raw material converted into a useful form in the works. Now, at present the marketable value of the alumina and agglomerated carbon necessary to the production of one kilogramme of aluminium (2·1 kilogrammes of alumina, 600 grammes of carbon), is about 3 francs; this sum, added to the cost of the energy employed in decomposing the combinations, is therefore, under the present circumstances, the lowest that can be fixed as the limit below which the price of aluminium cannot fall, but to which it can approximate; on this basis we can decide for a number of years for what purposes aluminium can be used, and for what it cannot, on account of its price.

We must not lose sight of the fact that in discussions relating to the price of a metal it is generally much more rational to refer to the unit of volume than to the unit of mass. Now, the density of pure aluminium varies from 2·6 to 2·7, according to the amount of work to which it has been subjected; it is therefore from three to four times lighter than most other metals, and its price, considered according to its volume, falls in the same proportion. For an equal volume aluminium at 5 francs would cost the same as copper at its lowest valuation; the extraordinary abundance of the raw material will, when its value is once established, protect it from fluctuations; and moreover, as it can take the place of copper to a certain extent, it will perhaps help to regulate the price of the latter.

Whatever its future may be, it cannot be sketched out until we are well acquainted with its properties. They are as yet very imperfectly known, for the aluminium used up to the present has been much less pure than that now in the market. Now, comparatively small quantities of impurities, such as silicium and iron, considerably impair its qualities. Besides, laboratory experiments do not give a correct idea of all the elements of the question. A defect, which seems of capital importance in the laboratory, becomes insignificant in practice, and *vice versâ*. We will now endeavour to give an idea of what is known of aluminium at the present day, confining ourselves to those of its properties that are of immediate practical use. We shall intentionally be very guarded in indicating its uses, knowing that we might otherwise frequently be led astray; we shall therefore confine ourselves to a few general observations. But first, we should wish to give our readers an idea of the remarkable works at Neuhausen, at present the most important in the aluminium industry.

At Neuhausen, as at Froges, aluminium bronze is prepared directly by the Héroult process, and pure aluminium by the Héroult-Kiliani method. The tendency is, however, to abandon the direct production of bronzes and keep to aluminium.

The Neuhausen Company have obtained from the Government of the Canton of Schaffhausen permission to use part of the falls of the Rhine, from which they are able to borrow 20 cubic metres per second; they would gladly have had more, but public opinion was aroused at the idea that one of the grandest scenes in Switzerland was about to be spoilt for ever. But the tourists may reassure themselves; the *détour* is not even perceived, and the falls have lost nothing of their beauty. Few factories are in such an advantageous position as to hydraulic power; at Lake Constance the level is absolutely free from strong tides, and the water is admirably clear. The fall is 20 metres, supplying a power of 400,000 kilogrammetres per second, or about 4,000 available horse-power; the production being at the rate of about 35 grammes per horse-power hour, we can see that the Neuhausen works are capable of producing more than 2 tons of aluminium a day. At present there are three dynamos at the works; two gigantic machines, the most powerful continuous current machines that have as yet been constructed; they each absorb 600 horse-power and give 14,000 ampères and 30 volts; and an exciting dynamo of 300 horse-power which gives 3,000 ampères and 65 volts. The two first are used exclusively for electrolysis; they are of the Brown type (Oerlikon) with 24 poles. The inductor, which resembles a toothed wheel, weighs not less than 12,000 kilogrammes. Fig. 1 represents one of these inductors.

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* *La Nature.*

The principal innovation that has been made in these machines consists in having placed them in a vertical position, the axle of the armature being coupled directly on the turbine. Fig. 2 shows the installation of turbines and dynamos at Neuhausen. The water comes in through conduits passing through the wall, and goes out through the floor; between these two conduits is the turbine, the axle of which comes out through the top of the cylinder. This arrangement offers several advantages; in the first place, transmissions are suppressed, and the continuous inspection of the collector is facilitated. It is very essential that these machines should work without stoppages, and without too much wear and tear. Now, we know that the sparks from the brushes rapidly destroy the collector. We can only avoid them by constantly inspecting the brushes, continually adjusting them, and keeping them always cut to a nicety. At Neuhausen, a workman is engaged exclusively for this work. At each pole there are five corresponding brushes on one support, so that without inconvenience one or two of the same series can be suppressed for a moment.

The work of inspecting the brushes does not involve the least risk, as the machine works at a low potential.

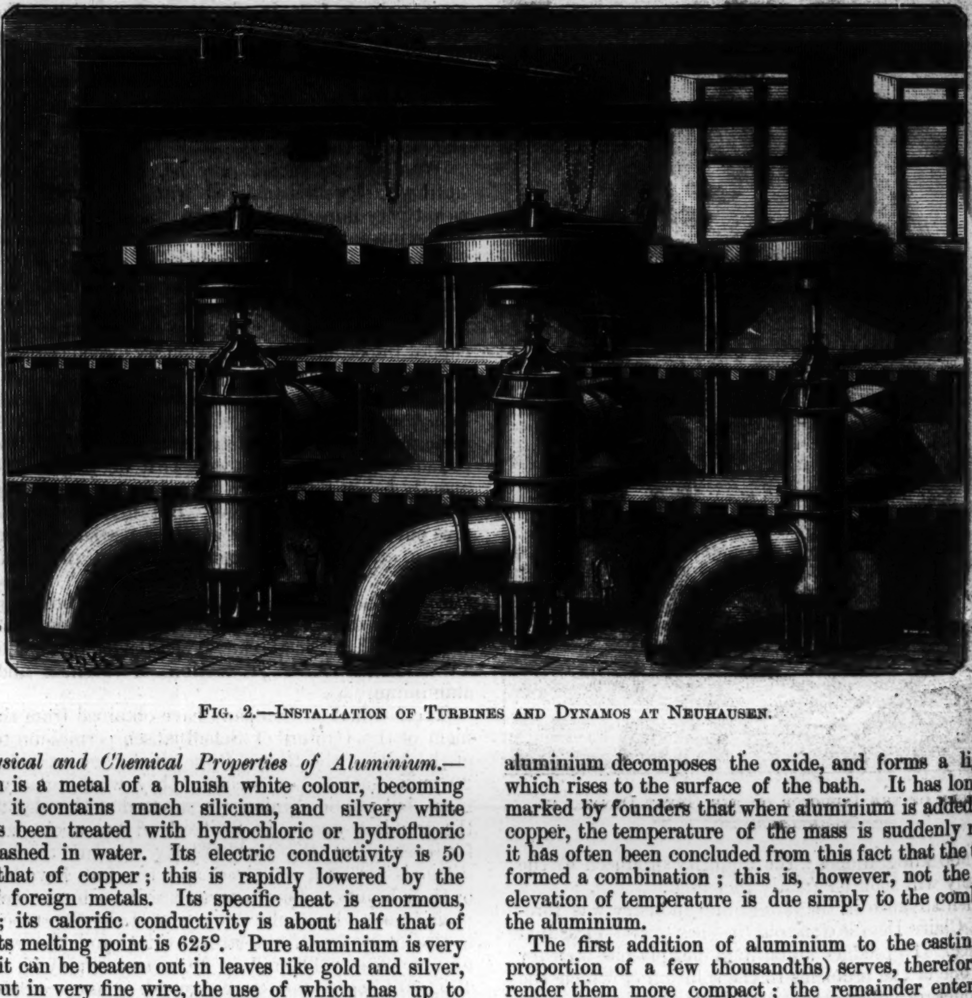

FIG. 2.—INSTALLATION OF TURBINES AND DYNAMOS AT NEUHAUSEN.

The Physical and Chemical Properties of Aluminium.—Aluminium is a metal of a bluish white colour, becoming grey when it contains much silicium, and silvery white when it has been treated with hydrochloric or hydrofluoric acid and washed in water. Its electric conductivity is 50 per cent. that of copper; this is rapidly lowered by the addition of foreign metals. Its specific heat is enormous, about ·22; its calorific conductivity is about half that of copper. Its melting point is 625°. Pure aluminium is very malleable, it can be beaten out in leaves like gold and silver, or drawn out in very fine wire, the use of which has up to the present been limited to the making of very small weights, but which are beginning to be used in tissues, fringes, &c. It is hammered and drawn out, stamped, and embossed cold. Its elastic properties, together with its density, are such that a bar of aluminium suspended from a wire and struck gives a very beautiful sound. It is the same with drums and goblets of aluminium. Perhaps one day aluminium may be used for making bells.

From a chemical point of view, it occupies an intermediate rank between the precious and the common metals. It is not readily attacked by the ordinary chemical agents; it does not become oxidised when cold either in dry air or damp air; sulphuric and nitric acids have little effect upon it; sulphurous gases do not tarnish it; it resists diluted acetic acid and citric acid, which enables it to be used for the table; in this case, however, it should not be exposed to the action of soda or alkalies in general. When in a molten state its properties are very different, it oxidises readily and enters into very stable combinations, which can only be decomposed under the influence of powerful chemical or electrical action. It is on the knowledge of this property that the methods of preparing this metal are based; in incandescent electrolysis it is necessary to secure the second product of the decomposition of its salt and to protect the aluminium itself from a second attack. For this reason, in the electrolysis of the alumina, a carbon electrode is employed, which, by burning, frees the bath from the oxygen withdrawn from the combination. This property, although inconvenient in many respects, is not so prejudicial to the employment of aluminium as might be supposed; it may, on the contrary, be turned to advantage, as it renders aluminium the most suitable metal for the de-oxidation of castings. We know, in fact, that copper, iron and steel in a molten state always contain small quantities of oxides, which impair their cohesion, become partly decomposed in the cooling, and form air holes. Now, aluminium decomposes the oxide, and forms a light scum, which rises to the surface of the bath. It has long been remarked by founders that when aluminium is added to molten copper, the temperature of the mass is suddenly raised, and it has often been concluded from this fact that the two metals formed a combination; this is, however, not the case; the elevation of temperature is due simply to the combustion of the aluminium.

The first addition of aluminium to the castings (in the proportion of a few thousandths) serves, therefore, only to render them more compact; the remainder enters into the alloy, to which it communicates remarkable properties. Aluminium bronzes and brasses have been carefully studied and are comparatively well known; its combination with iron has not as yet made so much progress. Opinions are divided, and for motives easily understood, many experiments are kept secret.

We will not conclude this first article without mentioning the interesting experiments made by M. Minet with a view to the extraction of aluminium from its fluoride. By a close study of the phenomena, and an exact determination of the constants of the bath, this clever and conscientious experimentalist has succeeded in effecting the electrolysis with an electromotive force of 4 volts, and a rendering of 30 to 35 grammes per horse-power hour. The works of Messrs. Bernard Brothers, at Creil, where M. Minet's processes are used, have produced for the last five years from 10 to 15 kilogrammes of aluminium per day with 25 to 35 horse-power, and we are told that they are about to work on a larger scale.

(*To be continued.*)

THE INTRODUCTION OF DRUGS INTO THE HUMAN BODY BY ELECTRICITY.*

By **FREDERICK PETERSON, M.D.**, Chief of Clinic, Nervous Department, Vanderbilt Clinic, College of Physicians and Surgeons, New York.

IT is with some degree of diffidence that I have ventured to accept the kind invitation of the former president of your society to read a short paper upon the subject of Electric Cataphoresis, for the reason that I have already written about all that I know concerning it, and that I already find myself placed, with many of my good friends, among hobby riders. Just as some of them are designated, or at least in danger of being so-called, Apostoli cranks, bacillus cranks, hydrotherapeutic cranks, and the like, so I have begun to hear faint whisperings of a similar term applied to myself in connection with anodal diffusion. But I wish to shun the imputation at once by stating that it is not a panacea for all human ills, that, indeed, it is useful in only a few conditions of the human system. Presuming, then, that its limitations as a therapeutic agent are many, it is in order to speak of it first historically and then practically.

While the diffusion of solutions through a membrane by the anode, and of the sarcous substance of the muscle from the anode to the cathode, had been known to electricians, the earliest investigation of its power to drive drugs through the human skin was made by Richardson in 1859 with morphine, aconite, and chloroform. Nothing further was written until 1886, when Wagner, Adamkiewicz, Lumbroso, Matteini, and others, re-introduced the subject in connection with chloroform. Corning and Reynolds made some experiments later with cocaine solutions upon the anode.

My own trials have been conducted since 1888, and the results published from time to time since then. (Electric Cataphoresis as a Therapeutic Measure, *N. Y. Medical Journal*, April 27th, 1889. Note on a New System of Exact Dosage in the Cataphoretic Use of Drugs, *N. Y. Medical Journal*, November 15th, 1890. Farther Studies of the Therapeutics of Anodal Diffusion, *N. Y. Medical Record*, January 31st, 1891.) The drugs made use of have been cocaine, chloroform, menthol, aconitia, onabain, strophanthin, carbolic acid, strychnine, succinimide of mercury, corrosive sublimate, iodol, iodide of potash, helleborin and the citrate, benzoate and chloride of lithium. Within a very short time experiments have been carried on by Cagney of London, Gärtner of Vienna, and Edison in this country, with the results of all of which you are doubtless familiar.

When my first paper was read before the section in theory and practice of the New York Academy of Medicine, the cataphoretic power of the galvanic current was still so little understood, that considerable incredulity, if not positive disbelief in the existence of such a power, was manifested by some who participated in the discussion. But so much has been accomplished since then, that there is no longer any doubt as to the actual diffusion of drugs in solution through the skin, and into the subcutaneous tissues by the galvanic anode, and it only remains to be established what actual therapeutic value, over and above any other means of administration, this particular method may possess, and to what disorders it may be especially applicable.

One of the reasonable criticisms has been that even if drugs were diffused as stated, exact dosage was impossible; but this is no longer a valid objection, since, very recently, it has become possible to make the doses accurate and certain.

A number of electrodes have been devised for cataphoretic purposes, some of them quite complicated, like those of Adamkiewicz, Munk and my own. But these are now no longer necessary. The cataphoretic electrode should be very simple—an ordinary metal one, either with or without a covering of cloth or sponge. Electrodes of tin are the cheapest, and the oxides may be easily scraped off when they collect. Gold or platinum would be better, but are very expensive, about equally so.

The ordinary sponge electrodes may be employed with solutions, such as those of lithium, iodide of potash, iodine and the like, where precision in dosage is not required; the plain metal ones, however, for the more careful administration of medicaments like cocaine, aconitia, strychnine, and helleborin. A narrow rim of rubber around the metal surface is needed to prevent evaporation. A disc of cotton cloth, or tissue or blotting paper, may be cut to fit the metallic surface, and upon this is dropped any desirable quantity of the drug in solution. The wet disc of paper is next the skin and prevents burning.

It is sometimes useful to prepare the skin a little before treatment by rubbing with ether, to dissolve out the oil globules. The anode being applied with the drug, the cathode may be placed anywhere upon the surface of the body and a current of any endurable strength turned on. The stronger the current the speedier the effect.

Besides the use of these simple electrodes, it is often desirable to make more extensive applications over wider areas. If, for instance, it were wished to diffuse a solution of lithium about a large joint like the knee, a sufficiently large strip of zinc is covered with sponge or cloth, saturated with the solution, tied around the extremity, to be then connected with the anodal rheophore. For diffusion through the whole body a bath-tub is used, one either constructed for the purpose or any ordinary bath-tub. The common bath-tub of our houses is readily converted into an anode by placing a large sheet of zinc on the bottom and connecting it with an insulated copper wire. The sheet of zinc is then covered over with a board to prevent its contact with the body. When the patient is immersed in the bath, he merely keeps one arm out to grasp the cathode and the circuit is made.

These are, in brief, the means by which drugs are introduced into the body, and it is clear that any soluble agent may be employed in some one of the ways described. The poisonous medicaments, which are to be administered in accurate doses, are kept either in solution (cocaine 10 to 20 per cent., helleborin one per cent.), or discs of filtering paper impregnated with solutions and dried, and containing a known quantity of the remedy, are kept on hand for the purpose. Such cataphoretic discs may be made by any pharmacist. (Otto Boeddiker, pharmacist, 564, Sixth Avenue, New York, makes them for my use.)

As regards, now, the therapeutical advantages of anodal diffusion, it would seem as though it had its widest applicability in maladies of the skin and mucous membranes, or of immediately subjacent tissues; but, of course, it may be given a much greater scope in conjunction with mineral, antiseptic and alterative baths, which is a problem for the investigations of others in the future.

Dermatologists have already evinced considerable interest in the subject, but I have no doubt that the rhinologist, laryngologist and gynecologist, who have so much dealing with mucous membranes will, in the course of time, avail themselves profitably of a power which promises so largely.

Surgeons have employed it frequently and successfully for local anæsthesia in minor surgical operations.

The physician cannot fail to take up the particular line pointed out by Edison, and make use of local applications by means of sponges, or generally by means of baths, for the purpose of influencing local and systemic affections, like gout and rheumatism.

I was led myself into making a study of electric cataphoresis by my own work in a neurological line, and my first experiments were conducted with a view to relieving pain. I received the suggestion after vainly endeavouring to combat severe supraorbital neuralgias in several patients. All known appliances and agents of the healing art had been ineffectual, blistering, electricity, aconitia and the progressive series of narcotics and anodynes, which generally terminate with the morphine habit. One of the patients had suffered from morphine inebriety for a year, but had recovered from that with her supraorbital anguish unassuaged. I found that 10 to 20 per cent. solutions of cocaine on the anode gave absolute relief in those cases for from 4 to 10 or 11 hours, and without constitutional effects of any kind. A deep analgesia was produced in the area covered by the anode. No doubt constitutional effects would ultimately result by indefinite continuance of the application.

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* Read before the Philadelphia Electro-Therapeutic Society, Thursday evening, February 12th, 1891.

Since that time I have made it a point always to use the cocaine solution in any sort of superficial pain in which I think the anode to be of advantage. The method does not mitigate neuralgic pains which owe their origin to lesions far back of the point to which the electrode is applied, as in disease of the Gasserian ganglion, or the idiopathic neuralgias of central origin; and it is here that cocaine cataphoresis has an actual diagnostic significance. If the pain is relieved by the treatment, the lesion is in the immediate neighbourhood or peripheral to the anæsthetised area, and this would furthermore suggest the possibility of permanent cure by neurectomy. This idea of the diagnostic value of cocaine cataphoresis is Dr. Starr's, and it has some sort of corroboration in a case of intense supraorbital neuralgia which I lately saw with him. A 20 per cent. solution of cocaine, used with a strong current for a considerable period of time, did not diminish the paroxysms of pain in the least. A few days afterward neurectomy was performed, and this also had no effect upon the neuralgia.

Cocaine employed in this way does not *cure* neuralgias of peripheral origin. All that is claimed for it is that it gives relief without producing constitutional effects, and is, therefore, superior to any narcotic given internally, and to any other local application.

Other local anæsthetics are chloroform, aconitia, onabain, strophanthin (Arnaud's), helleborin, menthol and carbolic acid.

Chloroform causes a dermatitis, and should be used only when counter-irritation is desired in conjunction with a transitory anæsthesia. I have employed chloroform cataphoresis in one case of cervical neuralgia with good effect. Helleborin and aconitia I have also used successfully, but the latter, while it gives rise to a deep analgesia, also causes painful smarting and burning, unless combined with a cocaine solution.

While my experience with the method has been chiefly in neuralgias of superficial nerves, I have not failed to give it a trial in other conditions where it seemed to be expedient. I have been using cocaine and helleborin with the anode in two cases of tic convulsif of late, placing the electrode over the trunk of the facial, or one of its branches. Whatever may be the explanation of its effect, these cases certainly show very great improvement, and a remarkable diminution of the spasm after each application, such as was not obtained from the employment of the electric current alone. In case of blepharospasm, cocaine cataphoresis practised near the outer angle of the eye produced a very marked change in the extent and frequency of the movement. I have no doubt, however, that the results would be better still if we had some drug to use with the anode which would act upon motor nerves in the same way as the local anæsthetics act upon sensory nerves; if, in other words, we had some trustworthy local paralytic. Atropia and curarin do not seem to answer the purpose.

There can be no doubt that the effects of the galvanic current upon nutrition are in part due to the cataphoretic transfer of molecules of protoplasm and liquid from one cell to another, or from a cell to a capillary vessel in the path of the anodal stream, and since the diffusion takes place more readily and more quickly in direct proportion to the current strength, it behoves us to employ as many milliampères as feasible in our galvanisation of the atrophied and paralysed extremities of poliomyelitis, chronic neuritis, and peripheral nerve trauma. Moreover, there would seem to be a possible advantage in the use of nutritive emollients in conjunction with the labile application of the anode to the atrophied member, just as they have been combined from time immemorial in the exercise of the aliptic art (massage). ("The Aliptic Art," by Frederick Peterson, M.D., Philadelphia *Medical News*, August 11th, 1883.)

As a last word, let me say that while the constant current has proved so useful to the medical profession for diagnosis, for stimulating nerve and muscle, for electrical endoscopy, for cauterisation, we must not neglect its cataphoretic property, by which remedial agents are diffused through the tissues and fluids of the body to improve nutrition, to produce anæsthesia, to relieve pain, to destroy germs, to modify morbid processes, and to make soluble chemical combinations with deleterious substances which frequently collect in the organism.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1890.

3,133. "Improvements in or relating to incandescent arc or semi-incandescent electric lamps." F. R. BOARDMAN. Dated February 27th. 8d. Refers more particularly to improvements upon the lamp known as the "Sun" lamp. In the present invention the inventor uses a block, circular in section, with three conical openings symmetrically placed around the circumference, each opening radiating from the axis of the block. The lighted area is thus considerably increased.

4,028. "Improvements in transmitters for electric telephones." C. L. W. FITZ-GERALD. Dated March 14th. 6d. The inventor provides in a suitable holder discs or plates which are preferably of carbon, and he insulates these discs or plates from each other by means of rubber or other insulating material at their edges. Across or in the space between these discs or plates he provides a division of a curved or angular form passing across the centre or thereabouts of the discs or plates and extending from side to side so as to make at one side of the centre a space which preferably is less than half the area of the discs or plates, and in this space he places the granulated carbon. 1 claim.

7,044. "Improvements relating to the lining of conduits for electric conductors." H. H. LAKE. (Communicated from abroad by David Brooks, jun., of America.) Dated May 6th. 6d. Dry swabs of cotton or cotton waste are run through the conduit, so as to dry the same or absorb the moisture that it may contain. The inventor then introduces into the conduit a composition of non-fusible powder or oil, or any plastic material, such as powdered soapstone, or soapstone and rosin oil. 6 claims.

7,094. "A method and apparatus for the application of electrical energy to the purposes of advertisement." A. R. UPWARD. Dated May 7th. 4d. Vacuum tubes or incandescent material take the form of letters which are arranged as required. In order that these devices may more effectually arrest and sustain the attention, the electrical circuits of the several letters and successive words of the advertisement are connected to a many-way self-acting switch actuated by any convenient small source of power such as clockwork or water-power or by a small electromotor fed from the same source of electrical energy; these circuits are so arranged with reference to the self-acting switch and the electric supply that the luminous effect is made intermittent, either the whole advertisement becoming alternately luminous and non-luminous or each word or words appearing in succession. 3 claims.

9,668. "Improvements in apparatus for elevating and lowering electric lights." J. P. HEBENDAHL, G. MILLER, and E. F. WARNER. Dated June 21st. 6d. Claims:—1. In a device for elevating and lowering electric lights, the suspending cable or rope, the drum or reel, its shaft and inclosing casing, the jaws having a sliding and pivotal connection with their support, and the hollow conical cap connected to the lamp, substantially as shown and described. 2. In a device for elevating and lowering electric lights, the supporting jaws having a sliding and pivotal connection with their support, and having their lower ends upturned to form a hook or beak which engages the hollow conical cap connected to the lamp, said cap having the screw-threaded plug or block in its upper end, having connection with the suspending wire, substantially as shown and described. 3. In a device for elevating and lowering electric lights, the pole or post having the supporting bracket or arm at its upper end, in combination with the drum or windlass and its shaft, and inclosing casing supported by said bracket, the jaws having a pivotal and sliding connection with their support, the enclosing casing formed on the end of the bracket supporting the pulley, the hollow conical cap connected to the lamp and the suspending wire, substantially as shown and described. 4. The combination with the lamp of the jaws having a sliding and pivotal connection with their support, and the conical support having a proximately ball-shaped upper end engaging said jaws at their upper inner ends, substantially as shown and described. 5. The combination of the pivoted jaws, the supending wire or cable, the conical cap, said wire having a screw plug or block connection with the upper spherical end of said support, substantially as described. 6. In a device for elevating and lowering electric lights, the drum or windlass, its inclosing casing, and its shaft having secured thereto near its lower end the ratchet wheel engaged by the pawl pivoted to the shaft supporting bracket, the shaft being adapted to receive a crank at its lower end, the suspending rope or cable secured to the hollow cap, and the jaws having the pivotal and sliding connection with their support, substantially as described.

9,797. "Improvements in and relating to electric circuit-controlling apparatus." W. W. ALEXANDER. Dated June 24th. 8d. The objects of the improvement are to produce a simple and reliable electro-mechanical apparatus adapted to operate various mechanisms by secret or pre-determined combinations of short and long impulses made upon a press button or upon an electric key indirectly acting upon a toothed wheel and pawls and levers. 17 claims.

9,956. "Improvements in heating by electricity." R. Kennedy. Dated June 27th. 8d. According to this invention the electricity which is converted into heat to be usefully employed is produced directly by magnetism, generated by alternating currents of electricity, which magnetism is produced, by currents drawn from any source of alternating current of electricity. The body, vessel, receptacle with their contents or chamber to be heated, is made of iron in most cases, so that the magnetism may be applied directly to it, iron kettles, boilers, coffee pots, flat irons, tailors-goose, soldering irons, and such like articles are heated by placing them over or between or within on electro-magnet having a laminated iron core, and through the coils of which is passed an alternating current of electricity. The magnetism produced in these iron articles, by the alternating currents in the magnet produces alternating currents within the masses of iron composing the articles, the whole energy of these currents is converted into heat in the iron. 4 claims.

11,240. "Improvements in electric arc lamps." J. Y. Johnson. (Communicated from abroad by L. Bardou, of France.) Dated July 18th. 8d. Claims :—1. The improved regulating mechanism for electric arc lamps, in which one solenoid is combined with a combination of levers and brake apparatus for the purpose of obtaining the lighting and regulating action in the lamp, substantially as described. 2. The improved regulating mechanism for electric arcs, comprising the combination of a solenoid and an arrangement for lighting and braking with a series of pulleys, so arranged as to enable both of the movable carbon holders to be supported by one cord, substantially as described with reference to the drawings. 3. The several arrangements and combinations of parts constituting the improvements in arc lamps, substantially as described.

12,422. "An electric pendulum for firing ships' guns." J. Jenc. Dated August 8th. 11d. Has more particular reference to means for effecting the discharge of a ship's guns at the proper moment for making a hit in spite of the presence, immediately in front of the gunner, of the smoke from guns worked from another or the same level, but more especially from machine guns up in the rigging. 4 claims.

15,006. "Improvements in converting electrical energy and in apparatus therefor." Rankin Kennedy. Dated September 23rd. 6d. The converter is double wound in its primary coils, one pulsating current traversing one of the windings and the other pulsating curent traversing the other winding in such a direction respectively that they act magnetically oppositely to each other, their combined effect being equivalent to one alternating current effect. 2 claims.

15,469. "Improved method of and apparatus for administering electricity to the human body." O. Imray. (Communicated from abroad by the Bethel Electric Medical Baths Company, Ltd., of Melbourne.) Dated September 30th. 6d. Consists in conducting the current into and out of the water in which the patient to be operated upon is immersed, no actual connection being made with any part of such patient. 2 claims.

15,741. "Electric fire indicator." T. R. Douse. Dated October 4th. 8d. Has for object a fire indicator or signal capable of, by heat expansion of air, alcohol, mercury, or other agent hermetically enclosed in a box, causing electric circuit to be closed between a battery and an alarum. 4 claims.

16,124. "Improvements in electric clocks." D. Fairgrieve. Dated October 10th. 8d. The chief features characteristic of the invention consist in providing means or apparatus for—firstly, driving the pendulum of the primary clock; secondly, transmitting the electric current from the primary clock to the secondary clocks in circuit; and, thirdly, for actuating the striking mechanism. 7 claims.

16,322. "Improvements in insulating cells for electric batteries." S. C. C. Currie. Dated October 14th. 8d. Consists of a cell, jar or vase provided with a depending rim or skirt adapted to be mounted upon a fixed insulating base having a recess formed therein in order to permit moisture to drip from off the depending rim or skirt of the cell, jar or vase without forming a liquid circuit from one cell to the other. Further consists of a cell, jar or vase provided with a depending rim, flange or skirt adapted for the reception of a fixed insulating base having a recess formed therein for containing an insulated fluid, in order that any moisture may be permitted to drop from off the depending rim or skirt without forming a liquid circuit; and further consists in making the fixed base in two parts or sections united by tenons and mortises and adapted to permit of the convenient separation of the sections thereof in order to permit the recess formed in connection therewith to be filled with an insulating fluid. 9 claims.

CORRESPONDENCE.

A Molecule of Electricity.

After our good old electro-chemical friend, Mr. Sprague, has given us his ideas of electric currents, in a contemporary, it is still more interesting to hear the other side. But where have we a master hand comparable at all with that grand friend of science, the late—much loved—James Clerk Maxwell. I wonder how many will take the trouble to go to his works and hear what he said about the matter.

In one part he speaks of *molecular charge*; but, true soul that he was, he says that we know nothing about it; at the same time, however, he remarks: "The complete investigation of electrolysis belongs quite as much to chemistry as to electricity. Of all electrical phenomena electrolysis appears the most likely to furnish us with a real insight into the true nature of the electric current, because we find currents of ordinary matter and currents of electricity forming essential parts of the same phenomenon." Note the significant expressions, *real insight*, *true nature*, *ordinary matter*.

"If it" (the molecular charge) "were known it would be the most natural unit of electricity." . . . . "Suppose, however, that we leap over this difficulty" (of ascertaining the actual molecular charge) "by simply asserting the fact of the constant value of the molecular charge, and that we call this constant molecular charge, for convenience of description, *one molecule of electricity*." The words, "for convenience of description," seem to be inserted to smooth down a little bit the wild or, as I think he terms it, "gross" idea or conception of "a molecule of electricity." It is slightly apparent though, I think, what was running in his mind—that electricity was, after all, ponderable, and was not something from nothing, a conclusion we seem logically bound to arrive at by some theories of its phenomena. In fact, it would seem that the idea of velocity can only be conceived of by accepting the notion of its being that of a ponderability; but whether it be the motion of ponderables at infinitely slow speed, or imponderables at infinitely high speed, does not seem to matter, as the one extreme is as difficult to conceive of as the other; but a fourth and further state we may yet know of, and meantime some say "faith," and some say "vortexes," and some say "ether squirts."

James C. Richardson.

April 22nd, 1891.

Specific Resistance.

The article by Mr. Moon on "The Absolute Units of Measurement," reproduces an error of definition, which is very frequent in England, relative to the unit of specific resistance. The specific resistance, *s*, of a body is defined by the relation

$$s = \frac{R\,a}{l}$$

where R is resistance; *a*, sectional area; and *l*, length; and for dimensions,

$$L^2\,T^{-1},$$

that is to say, the product of a resistance ($L\,T^{-1}$) and a length. It cannot therefore be properly expressed in "ohms per cubic centimetre," or in "microhms per cubic centimetre," but rather in *ohms-centimetre* or in *microhms-centimetre*; that is to say the quotient of the resistance of a body by its volume, and not by its specific resistance, which is more properly measured in ohms per cubic centimetre. Specific resistance is the product of a resistance by a length ($L\,T^{-1} \times L) = L^2\,T^{-1}$

C. G. S.

France.

Concentric Wiring.

It is with much pleasure I read in to-day's issue the letter from such an able man as Mr. H. Human, of the Guardian Office, expressing his views on concentric wiring, and must congratulate him upon being the first of the surveyors to take this matter up and express an opinion. Mr. Human is evidently aware of the danger consequent on keeping insulated wires separate from each other by wood or other casings. Nearly all electrical fires occur through damp, or bad joints, and metal casing appears to be the only reliable safeguard from such. During my varied experience I have been in the habit of running the two wires in a metal tube, which has the same effect as concentric wiring and the advantage that neither pole is put to earth. As Mr. Human points out, if a defect occurs between the two wires or from wires to metal tube, the contact produces a metallic defect and melts the fuse before any possible danger can arise, the metal sheathing being of much greater section than either the wire or fuse, makes it a perfect protection against fire, a high resistance (100 ohms) being much more dangerous than a low one (5 ohms).

In the past eight or nine years in London, I have used many miles of metal tubes with the positives and negatives enclosed, using a good quality wire of about 300 megohms per mile, which in any installation gives as high an insulation as is ever required by the supply companies, and never found a defect to cause a fire or other damage. There is no doubt, as Mr. Human in his letter points out, that twin wire with a light insulation between the wires and a good outside waterproof insulation should be used, and if this is enclosed in a metal tube, with a safety fuse in connection with the circuit, as is usual, on each pole, no system could possibly be more permanent, or safer from fire risks and the ravages of vermin.

I am of opinion that it is not advisable to use concentric wiring with the outside covering to earth, as it would cause many troubles to other houses on the same supply company's mains. A much cheaper insulation than rubber could be used if the wires were run in metal tubes, because as long as the metal tube is dry inside and the wires $\frac{1}{8}$th of an inch apart, no possible accident from leakage could occur. According to the Phœnix Company's rules, the wires should be 1 inch apart, enclosed in a wood casing and "run in with asbestos putty." Electrical contractors, of course, know that asbestos putty and casing are most inflammable, and that the farther the wires are kept apart, the more serious the damage is liable to be. They have to contend with the inexperience of some of the fire office inspectors, who will not listen to the advice of the contractor, the most likely one to know the origin of fires caused by defective electrical work. Mr. Human has opened up a subject which wants investigating, and which, if adapted, will place the fire office rules in a much more reliable and safer form. The concentric, or running wires in metal tubes, is a great step towards perfecting and making the electric light safe.

J. G. S. Cunnington.

May 1st, 1891.

Mr. Human's able letter on concentric wiring appearing in your paper of last week is welcome, as bringing forward a system of house wiring which will attract much attention.

Contractors are frequently placed in the difficult position of having to carry out the wishes of architects with regard to wiring the interior of buildings with due regard to the decorations and the regulations of the fire offices, wherein wood casing and an abundance of cut-outs are rigidly commanded. Arguments are useless, when the Inspector ejaculates "who takes the fire risk, the architect, or the fire offices." The fire offices sometimes remain victorious.

Concentric wiring of buildings offers so many advantages where decorated ceilings or walls have to be studied, or in modern buildings erected with iron joists and girders everywhere, that the good features have only to be known, to be appreciated.

I wished recently to use this method of wiring in a country mansion, a self-contained installation; the specification, however, compelled compliance not only with the wishes of the consulting engineer, but also with the requirements of sundry fire offices; therefore the existing system of double wires, wood casing, &c, had to be adhered to.

My firm is now engaged on a large building, which will have a self-contained installation, *i.e.*, with its own boilers and generating plant. It is a case where concentric wiring would answer admirably; until, however, all the fire insurance offices are better acquainted with this system of wiring, it would be two hazardous for contractors to make use of it on a large scale.

The time is probably not far distant when this method will be recognised and used.

Sidney Sharp.

May 5th, 1891.

In a leaderette on Andrews's concentric wiring in your last issue, referring to the action of the Fire Offices' Committee, you say, "The majority proved to be against the new system. A letter was consequently written to the Mersey Dock Board giving expression to the disapproval and corresponding advice."

As sole agent for Messrs. J. D. F. Andrews & Co. in this district, and having been instrumental in obtaining the contract for the lighting of the warehouses named, I must ask permission to point out that your informant has decidedly overstated the position taken up by the Fire Offices' Committee. In their letter to the Dock Board they say, in so many words, that they "are not in a position to express an opinion" upon the merits of the system, and on this ground alone "deprecate the adoption of a system of which, so far as they know, there has at present been no practical experience."

This is very different, indeed, from actively opposing the system as your report seems to signify is the case, and leaves the door open for a reconsideration of their decision as soon as they have knowledge of the numerous installations where the system has been for some years in use and giving the greatest satisfaction. As a matter of fact, several of the leading offices have already intimated their approval of it, and their perfect willingness to accept it; and as the Mersey Dock Board prefer galvanised iron to wood casing in their fireproof warehouses, there is every prospect of the discussion being very speedily terminated to the satisfaction and benefit of all parties by the insurance offices unanimously deciding to place concentric wiring in the category of good things.

Wilfrid S. Boult.

May 4th, 1891.

Electromotive Force and Difference of Potential.

In order to properly grasp the difference which physically exists between an electromotive force and a difference of potential, the following are two very simple and opposite examples which show very clearly this difference, and which are, I think, worth publication:—

If one considers a charged condenser, and we suppose that the battery which has charged it to be destroyed, then there exists between the two plates a *difference of potential*, although the electromotive force which has given rise to it has ceased to exist. If, on the other hand, we consider a transformer, the primary circuit of which is connected to an alternator, slightly excited so as not to burn the secondary circuit, which we will suppose is closed on itself on short circuit, then there exists in this secondary circuit a current, and, consequently, an *electromotive force* producing a current, but it is absolutely impossible to find the least difference of potential between two points in any part of the secondary circuit. These two cases establish very clearly the difference between these two physical quantities, since it is always possible to have the one without the other.

C. G. S.

France.

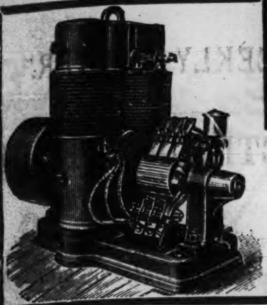
Examination Questions.

On page 562 of your last issue, you say that you wish to point out that the questions set in a certain electrical examination were carelessly worded, but the only instance you give in support of your statement is one which shows that it is your criticism which is thoughtless and not the question referred to. A battery whose electromotive force is 1·5 volts is not necessarily one which polarises with a current of a quarter of an ampère; and even if it were, the examiner might purposely have left the fact for the candidate to point out.

W. E. Sumpner.

[Our remarks were mainly intended to convey the impression that if it were afterwards required to find the output of the battery, the current would probably be multiplied by the open E.M.F. instead of by the difference of potential at the terminals when the circuit was closed. The great differences which may exist between the voltage readings on open and closed circuits are not always recognised even by those who report upon batteries, and it is not likely, therefore, that an elementary student would point out the dropping of E.M.F. by low external resistance, or by polarisation.—EDS. ELEC. REV.]

AN ELMORE SHAREHOLDER.—We regret that through an unluckly mischance the letter of "An Elmore Shareholder" has been lost. The report of Prof. Unwin which was omitted from that letter has reached us, and if the writer will favour us with another copy of his communication, we shall feel much indebted to him for his trouble.—EDS. ELEC. REV.



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3827

CRYSTAL PALACE ELECTRICAL EXHIBITION.

1891–2.

An ELECTRICAL EXHIBITION, on the same lines as that which proved such a brilliant success in 1881, will be opened at the Crystal Palace in November, 1891, and be continued for some months.

No charge will be made for space. Medals and Certificates will be awarded.

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HENSHAW RUSSELL,
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Crystal Palace,
May, 1891.

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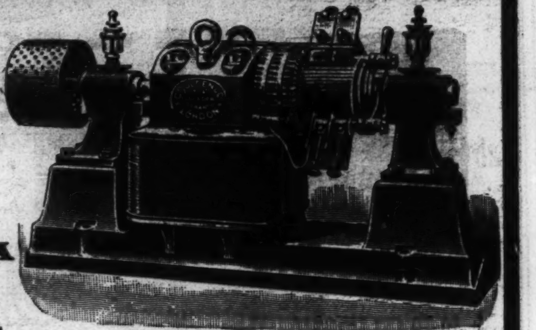

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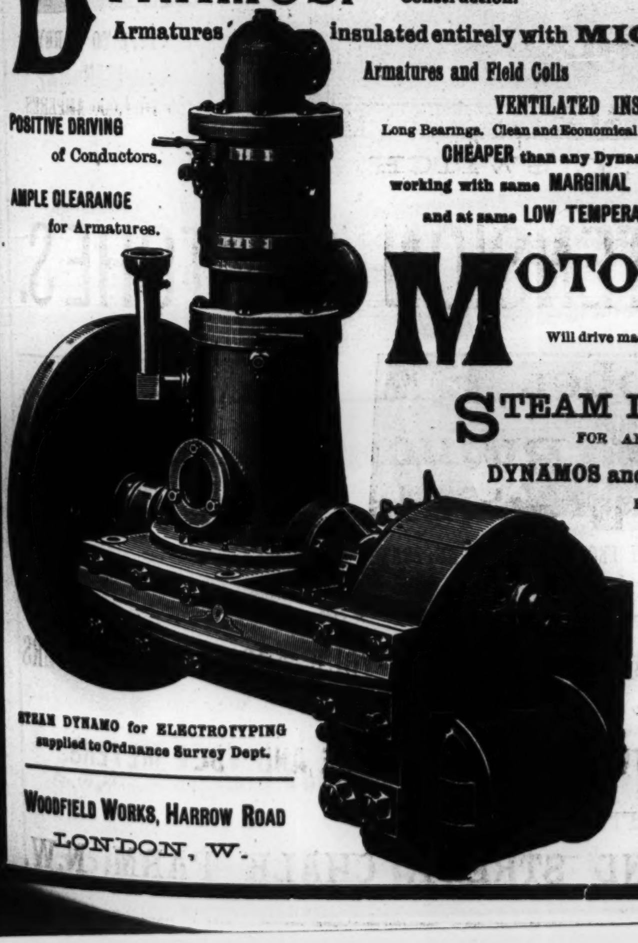

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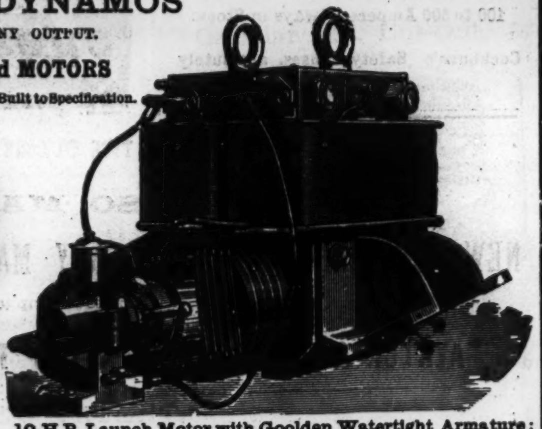

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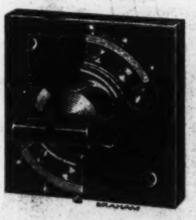

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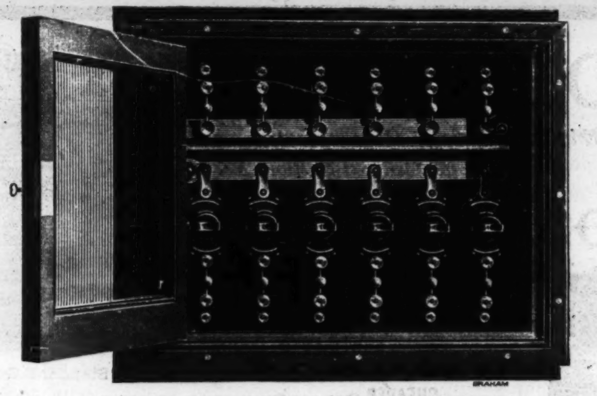

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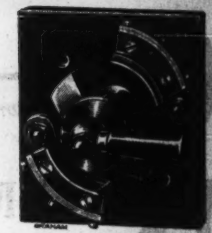

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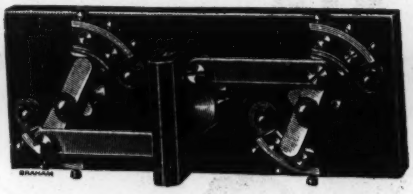

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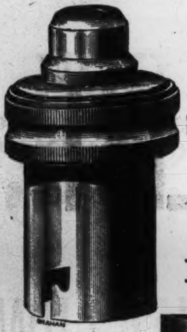

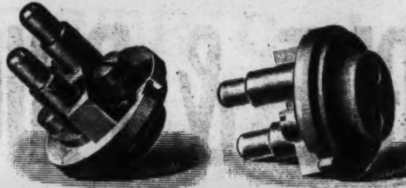

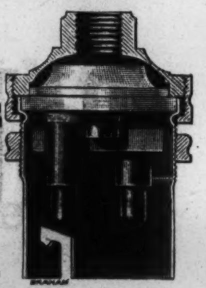

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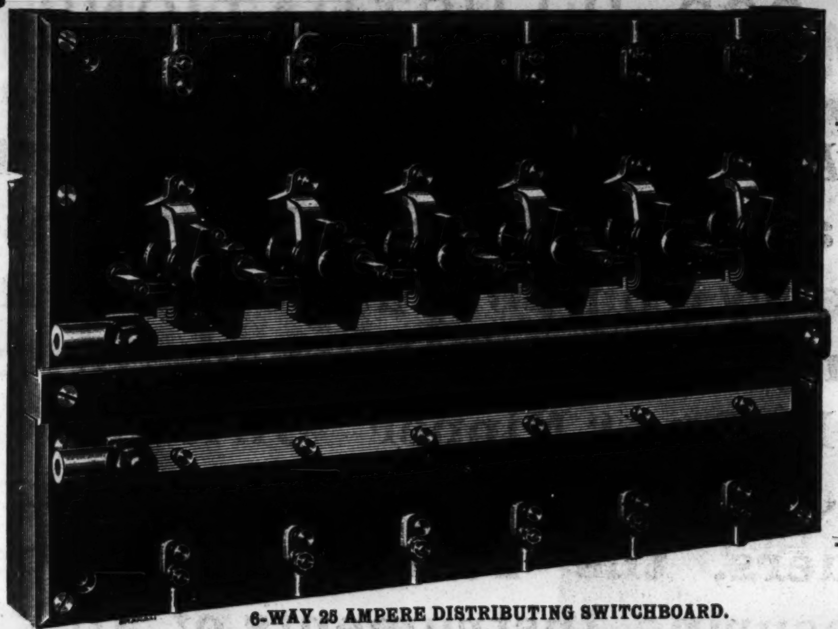

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Switchboards made to any Specification.

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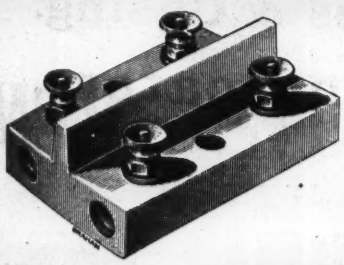

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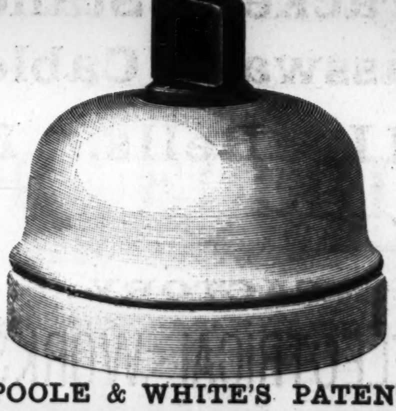

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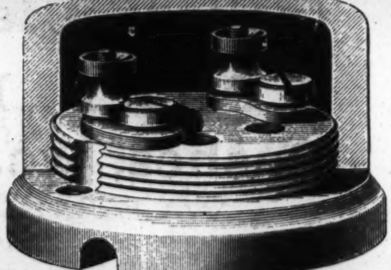

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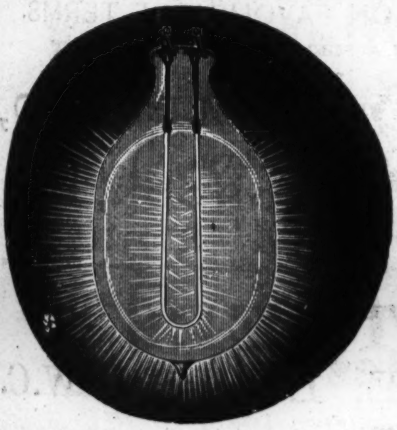

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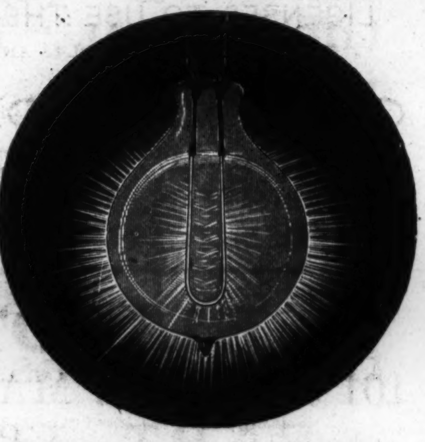

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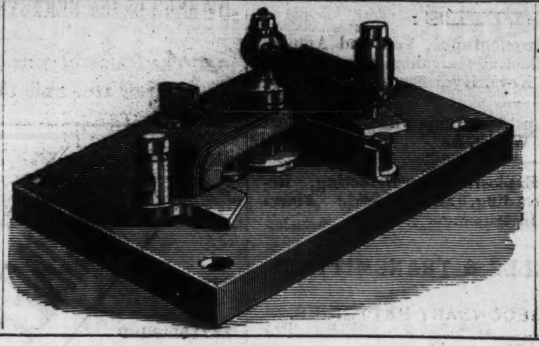
Mounted on slate base, and impossible to arc owing to the loose handle. Best materials used throughout.



Cat No.	DESCRIPTION.	Am pères.	PRICE.	
			Rough Finish.	High Finish.
65	To carry	30	11/6	14/-
66	"	60	21/6	26/-
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NEW TYPE "G" AMMETER SWITCHES.

FOR LARGE CURRENTS. RIGID HANDLES. PATENTED.

This is an exceedingly strong and well-made Switch and particularly suitable for heavy currents. It has a brass plate contact arm as in the "F" Switch, save that in this case the two contact plates are at opposite diameters of the Switch. It is mounted on slate base, and although not provided with special springs the break is remarkably quick, owing to the pressure of the bent brass contact plates. Brass plates are provided on which the contact arm rests when the Switch is "Off." The one-way is for mains for switching on and off, while the two-way is suitable for switching through ammeter or line, or for two circuits. If used for two dynamos it is made with a wide break between the contacts to preclude the possibility of short circuiting.

Catalogue No.	DESCRIPTION.	Ampères.	PR'CE. Each.
71	1-way } with handle same shape as Fig. 770.	30	14/-
72	2 "	"	16/-
73	3 "	"	19/6
74	1 " with handle, as per illustration, Fig. 776...	60	26/-
75	2 "	"	28/-
76	3 "	"	31/-
77	1 "	100	35/-
78	2 "	"	38/-
79	3 "	"	42/-
80	1 "	200	50/-
81	2 "	"	55/-
82	3 "	"	60/-
83	1 "	500	80/-
84	2 "	"	86/-
85	3 "	"	92/-
85a	1 " } with double handles	1,000	150/-
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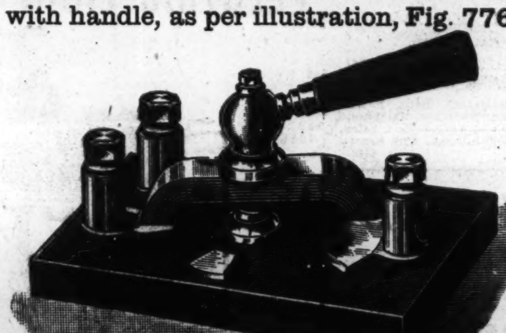

The Company have in stock a small quantity of these Switches fitted on mahogany bases, at reduced prices.

Made with back plug connections for Switchboards at 3s. per connection extra.

The two-way Switches specified above are also made with extra wide break. Prices same as three-way for same current.

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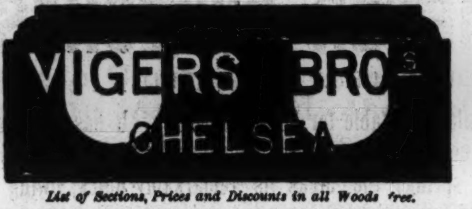

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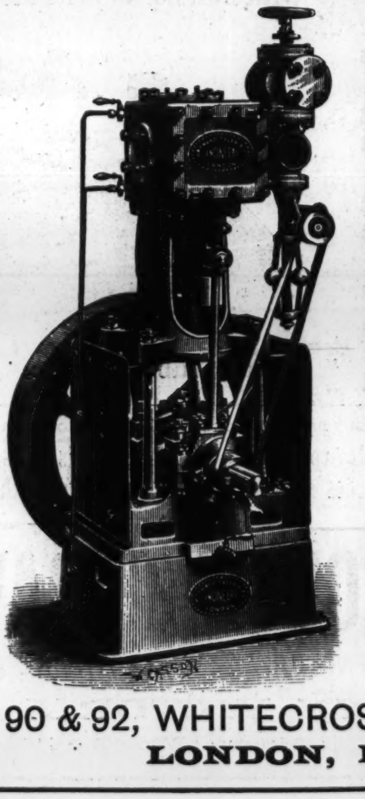

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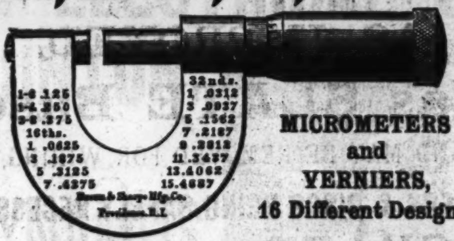

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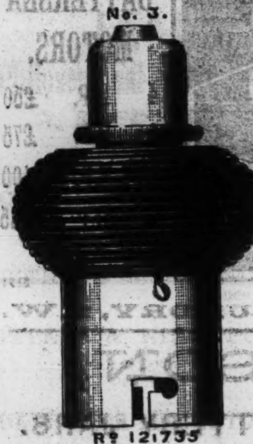

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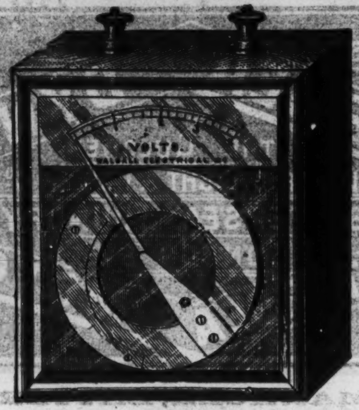

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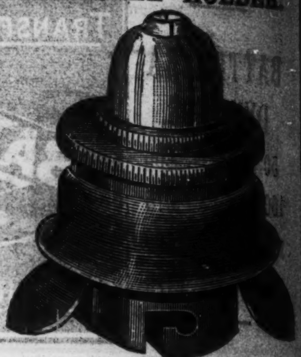

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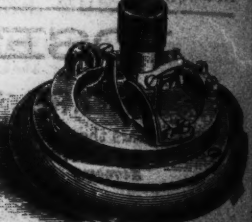

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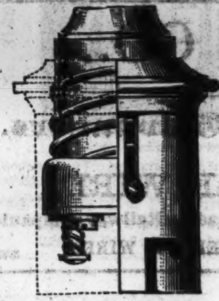

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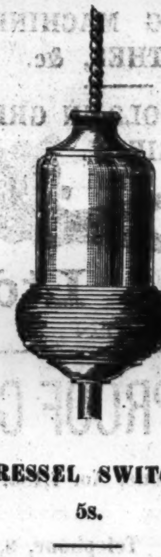

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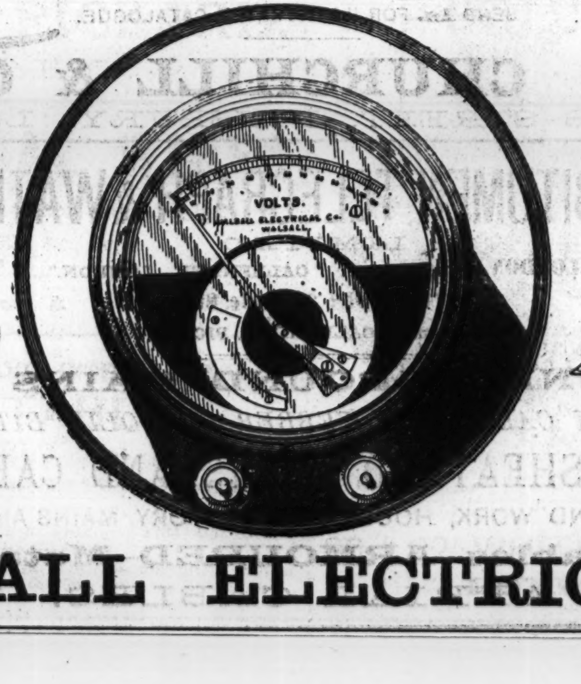

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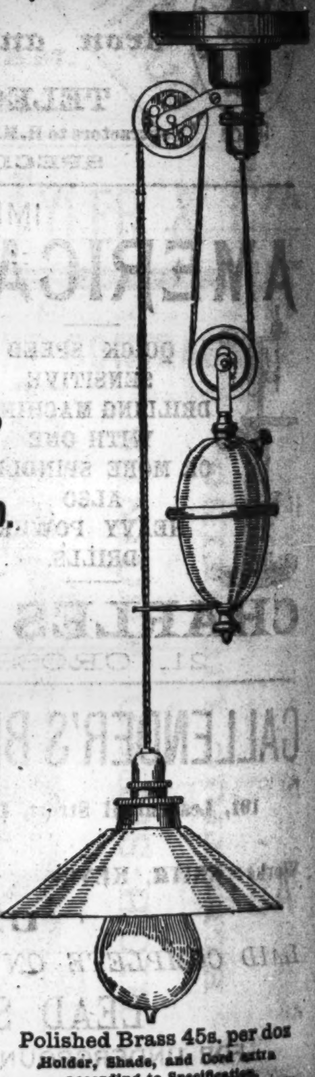

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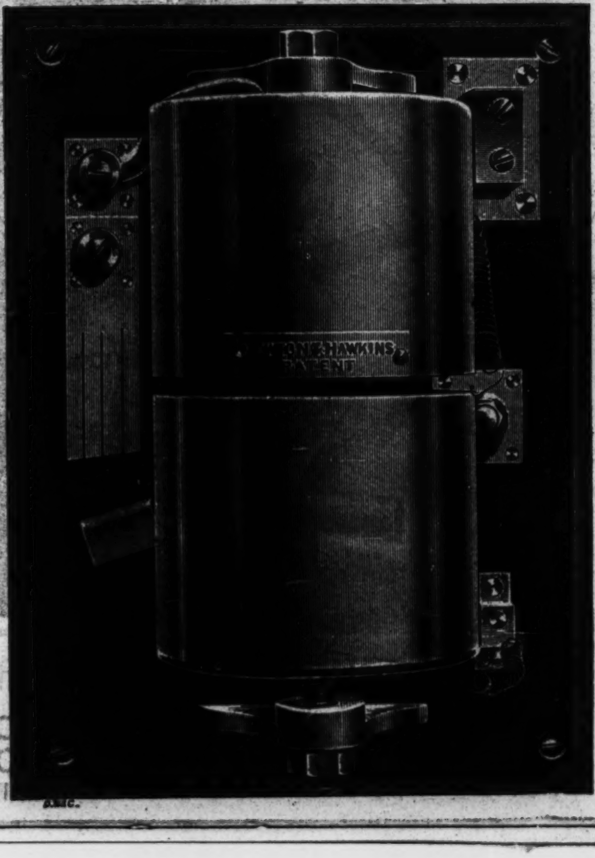

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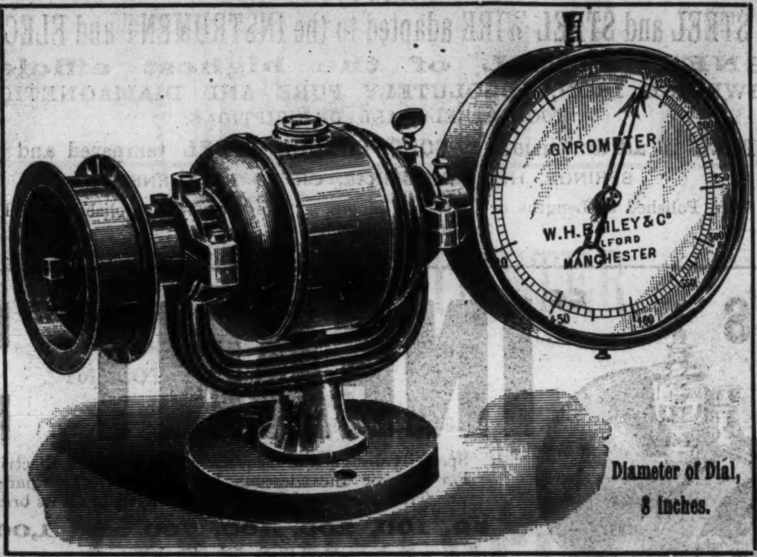

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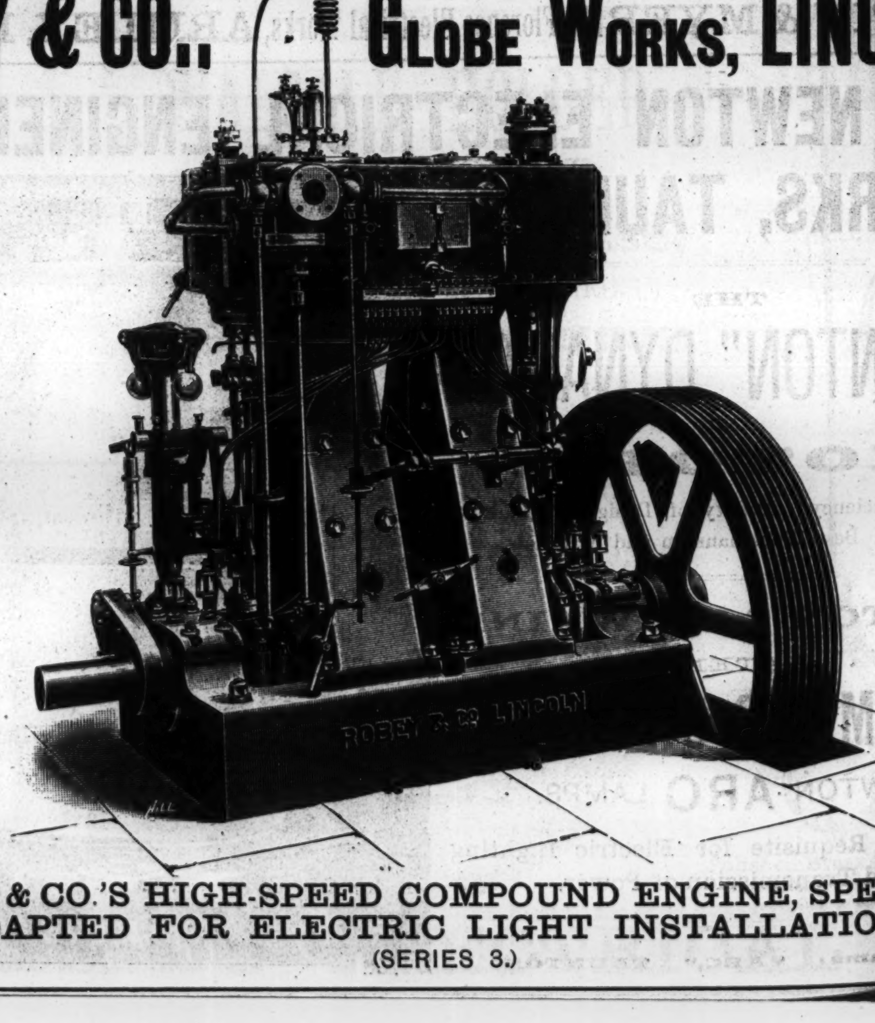

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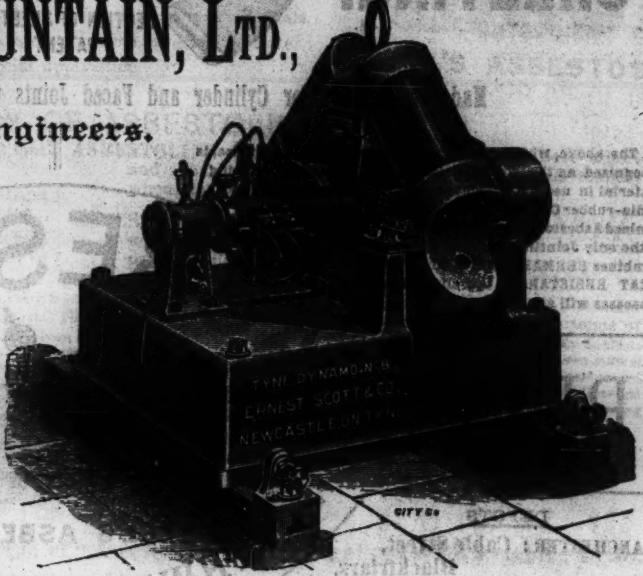

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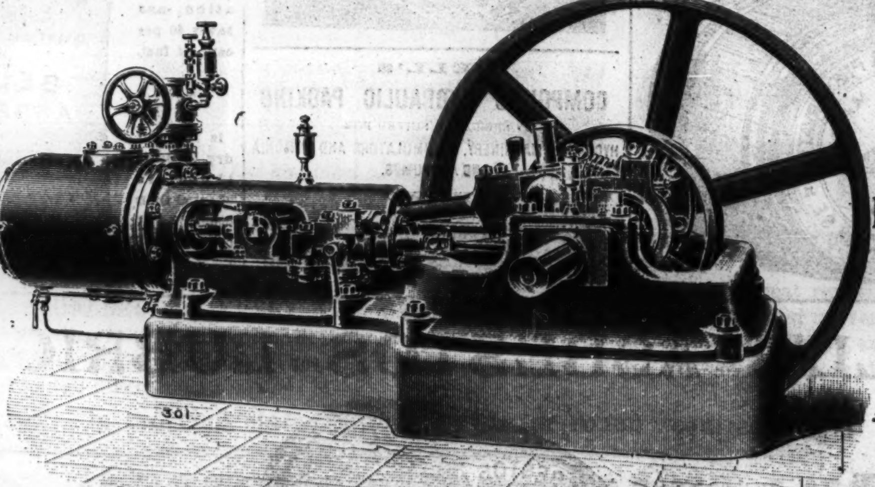

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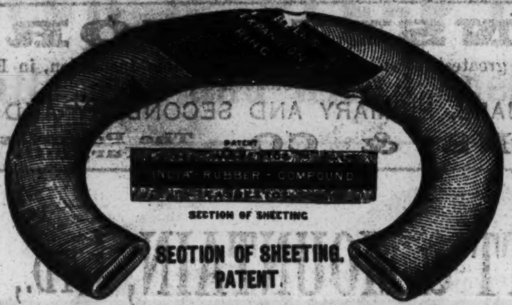

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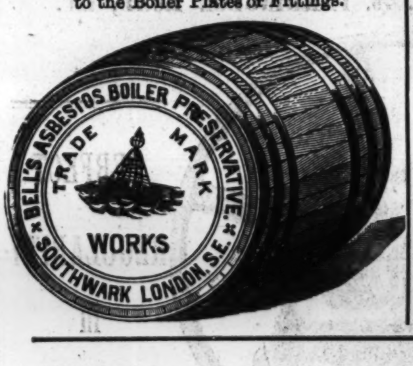

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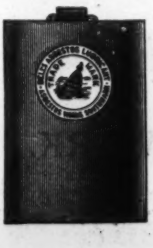

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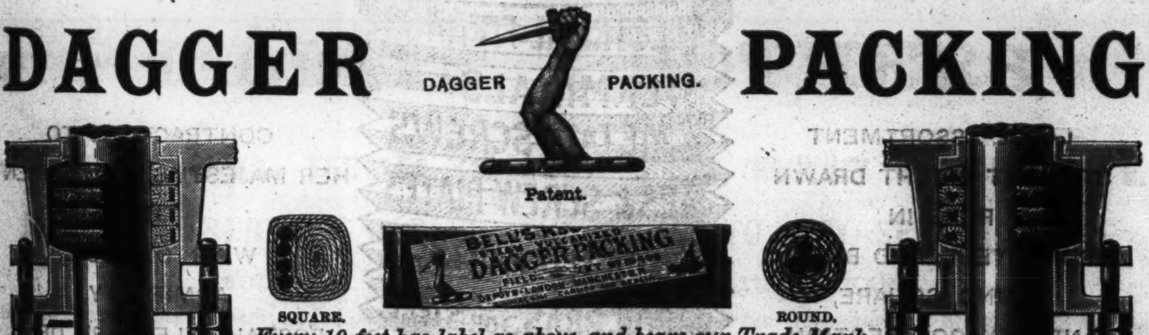

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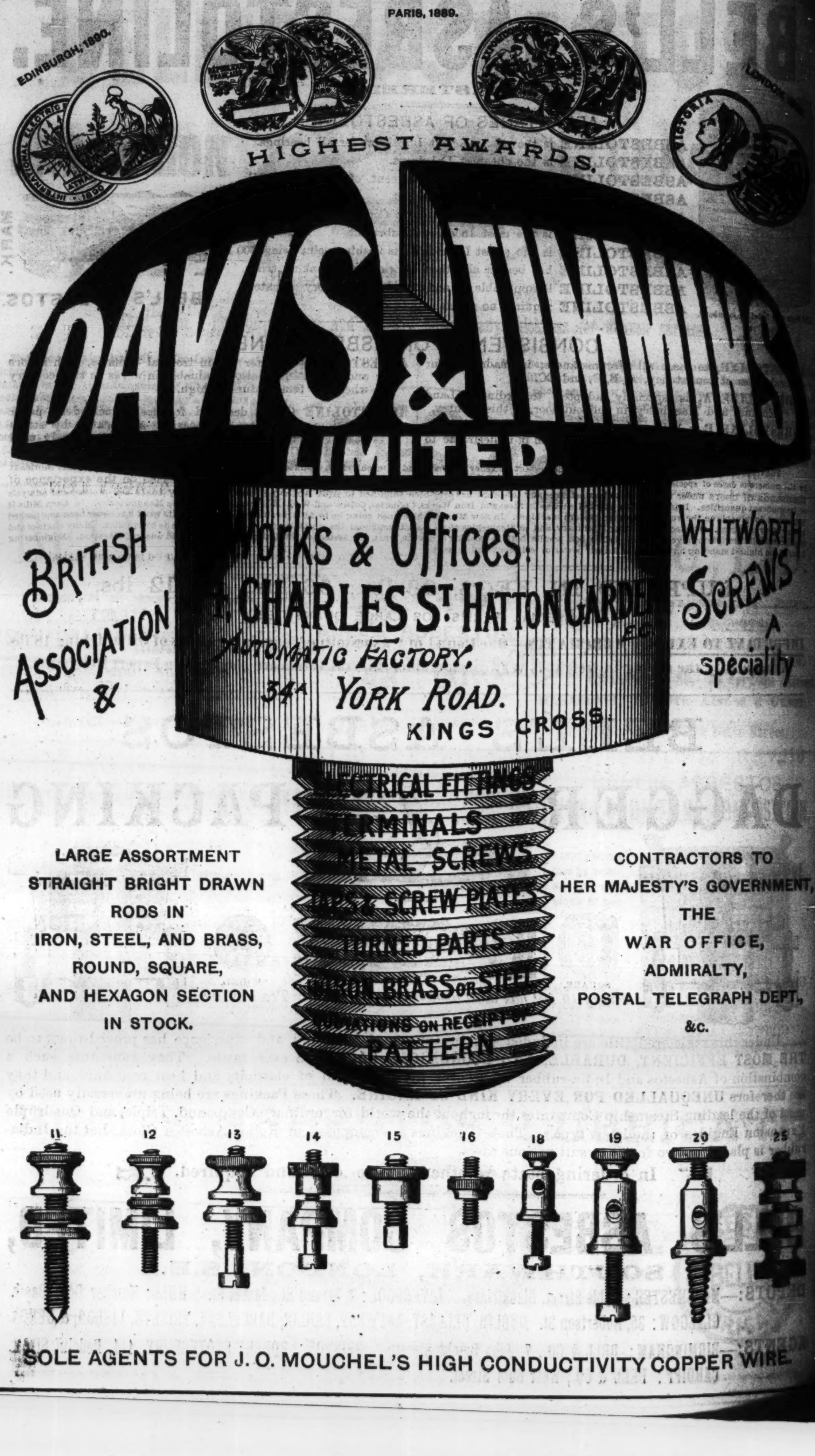

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